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High Power Switch Design

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13. ABSTRACT *(Maximum 200 words)*

The complete manufacturing design of a high-power, high-repetition-rate switch has been developed. The switch will be capable of continuous operation at 100,000 volts, 100 kilowatts of average power, 100 joules per pulse, and 1000 hertz pulse repetition rates into a low impedance load. The inductance is minimized, as far as consistent with the other requirements, and the switch is designed for long life. The switch is a trigatron type spark gap with a high-pressure hydrogen-gas fill. The design is based directly on previous development of such devices by NSWCDD. The design includes an integrated fluid cooling system and a 100 kV, 1000 Hz trigger system. The design is capable of scaling to higher voltages and power levels. The manufactured switch will be vacuum sealed, and is designed to meet both military and commercial shock, vibration, temperature, and other environmental conditions.

14. SUBJECT TERMS

Triggered spark gap, High-voltage switch, Pulsed-power switch

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16. PRICE CODE

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FINAL TECHNICAL REPORT
IN ACCORDANCE WITH CDRL A001
CONTRACT N60921-94-C-A345
BY

CENTRAL CONNECTICUT ENGINEERING, INC.
UNIT A-4, 1275 CROMWELL AVE.
ROCK HILL, CT 06067

JANUARY 31, 1995

1. INTRODUCTION

This final report is submitted by Central Connecticut Engineering, Inc. in accordance with CDRL A001, Contract number N60921-94-C-A345, for research and development of a High Power Switch. The switch is a triggered spark gap with the following requirements:

High voltage hold-off of 100 kV

Pulse repetition rate of 1000 Hz

Energy per pulse of 100 J into a low impedance load

Average power switched of 100 kW

To meet these requirements a high-pressure trigatron-type spark gap has been designed in accordance with previous designs by NSWC, along with a trigger generator. The status of the project is described in the following sections.

The spark gap overall design is shown in drawing G610 and critical dimensions in drawing INSLSTR.

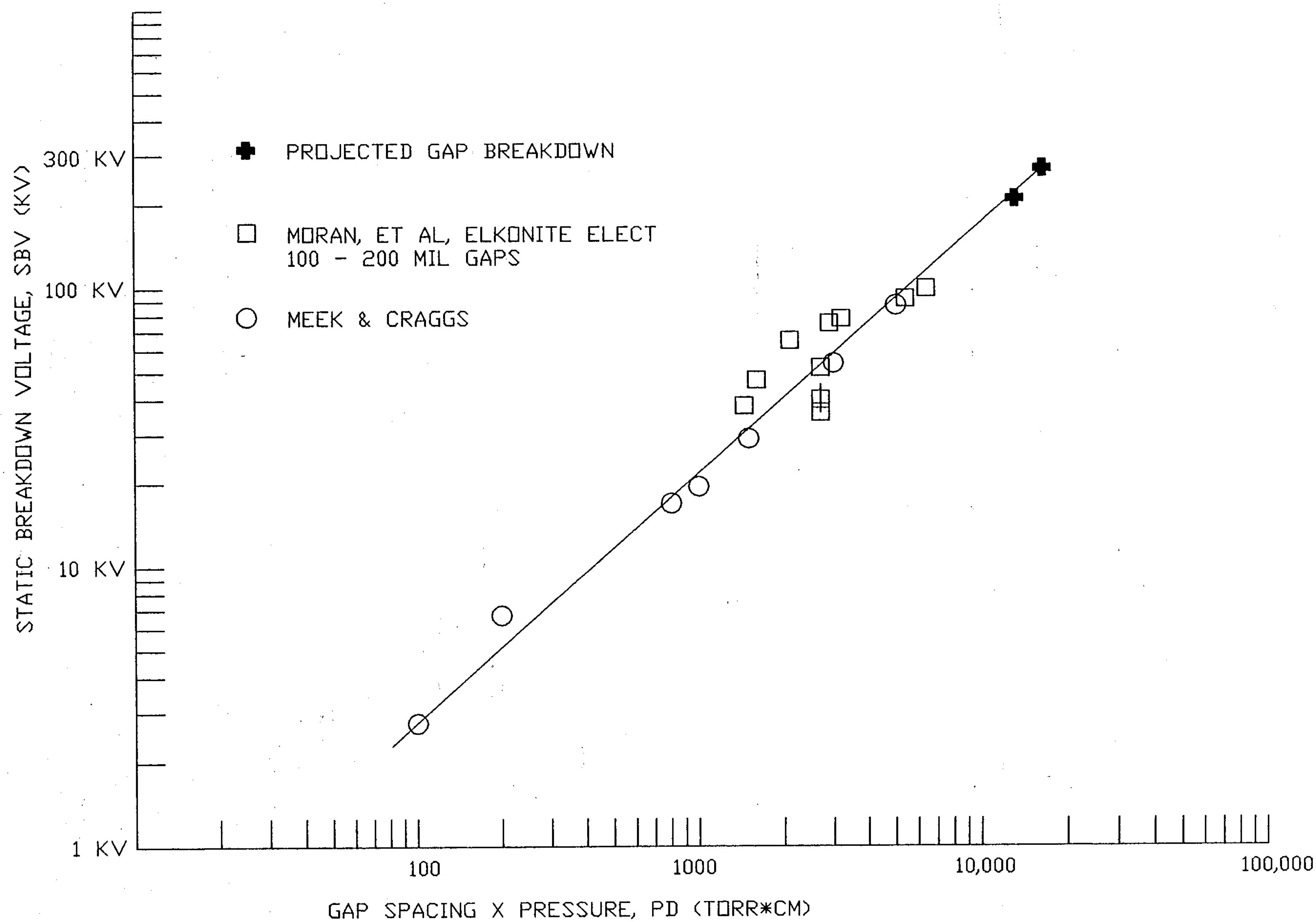
2. ELECTRODES

At the beginning of the project a meeting was held at NSWC to discuss the basic requirements and earlier work on the device. NSWC provided further published work and hydrogen breakdown data. At that time it was decided that the optimum E-E spacing might be near to 0.25 inches with trigger to adjacent electrode spacing of 0.16 inches, and with operating pressures of 400 to 500 PSI. Some of the breakdown data were re-plotted along with data taken from Meek & Craggs book on gas breakdown. The results are shown in Figure 1. The NSWC data shows some scatter but is in fairly good agreement with the Meek & Craggs information. In Fig. 1 the data is extrapolated to higher voltages. With an E-E spacing of 0.25", the SBV at 400 PSI is about 210 kV, and at 500 PSI is about 270 kV. These figures appear to be suitable for 100 kV high PRR operation.

These dimensions were used in the design of the spark gap, shown in Drawings G610, G610-xxx, A610-yyy, and the corresponding drawings for the de-mountable version.

Both the main electrodes and are to made of Tungsten matrix/Copper material - Metallwerk Plansee K25 or equivalent.

The trigger electrode tip uses Tungsten with a small percentage of Rhenium to improve its mechanical properties. The trigger electrode tip is 0.125" dia., brazed into a 1/4" copper support rod coaxial with the trigger insulator. In the demountable gap



PROJECTED GAP BREAKDOWN
MORAN, ET AL, ELKONITE ELECT
100 - 200 MIL GAPS
MEEK & CRAGGS
STATIC BREAKDOWN VOLTAGE, SBV (KV)
300 KV
100 KV
10 KV
1 KV
100
1000
10,000
100,000
GAP SPACING X PRESSURE, PD (TORR*CM)

FIGURE 1

version a copper extender is used. The design as shown requires a braze, for good thermal contact. The extender could be threaded for ease in replacement if needed.

The main electrodes have a flat diameter of 2.3", with the dimension driven outward by the cooling channel needs. The outer radius of the electrodes is 0.55", slightly more than twice the E-E space. This radius has been found in the past to offer a reasonably close approximation to a Rogowski shape, with minimal field enhancement at the beginning of the curvature.

The main electrodes are to be brazed with their inner copper cooling structures to the steel support plates and outer envelope structures.

All of the braze joints are shielded from exposure to the main arc, or from an area where an accidental breakdown might occur. This precaution is necessary since the gold/silver/copper braze alloys have a low vaporization temperature and, if struck by an arc, may easily contaminate the insulators.

The E-E spacing may be easily altered by changing a spacer behind the opposite electrode. As shown the spacer is about 1/8".

3. ENVELOPE AND HIGH PRESSURE CONSIDERATIONS

3.1 STEEL ENVELOPE

While the E-E spacing is designed for internal pressures of less than 500 PSI, the envelope design considered an internal pressure of 1000 PSI. This was done to accommodate some over-pressure during operation - although the active cooling should prevent gross over-heating, and pressure surges during a fault.

The material to be used for the outer envelope - the pressure containment - is 304 stainless steel. (It is also important to avoid magnetic materials.) As a consequence most of the brazing operations will require a very dry hydrogen furnace (not a significant problem for any vacuum-tube-grade manufacturer).

The inner diameter of the envelope was determined by the outer diameter of the main electrodes and the clearing to the wall. An annular spacing of 0.55 inches was selected, giving a minimum envelope ID of 4.5".

Both deflection and distortion of the end plates and the outer cylinder were calculated for a variety of diameters and thicknesses. Rourke's formulas for stress and strain were used. A yield strength of 30,000 PSI was used. The result was a choice of 3/4" thickness generally, operated at 8% of yield in the worst case, the plate at the high voltage insulator end of the gap.

3.2 INSULATOR SEALS

The most difficult problem posed by the high internal pressure is that of the ceramic-metal seals. The ceramic to be used is 94% Alumina (Wesgo AL-500 or equivalent). The ceramic itself is quite strong, especially if used in compression - over 300,000 PSI strength. In tension or flexure the strength is about 40,000 to 50,000 PSI, but since the material is very brittle it may be easily shattered by a localized stress concentration or flaw. The seals structures also require fairly thin metal at the seal since a perfect thermal match is never quite possible, even with the use of Kovar or Nickel/Iron 42 alloy. The result is that the ceramic diameter should be as small as possible to minimize the total sheer force applied to the ceramic seal metal OD. A further worry is that the braze operation may weaken the metal by inter-granular penetration, or a change in the crystal structure.

For the main insulator a 2" nominal diameter was chosen, with tapered seals. The tapered seal - at about 15 degrees - is one of the strongest. Here the insulator is used so that the seals are put under further compression by the internal pressure of the spark gap. Very thick seal metal, 0.062, is used, but may be worked at up to 20% yield in the worst case (less than 10% at nominal).

The trigger ceramic nominal diameter is much smaller, only 3/4", and poses much less of a problem. Ordinary coaxial compression seals are used, operating at moderate stress levels.

3.3 DEMOUNTABLE STRUCTURE

A demountable version of the same structure is shown in drawing G611 and associated G611-xxx and A611-yyy drawings. The gap is assembled in three sub-assemblies:

Opposite electrode and main insulator

Adjacent electrode and steel enclosure

Trigger assembly

The sub-assemblies are joined by the use of Varian-type Conflat flanges with copper seals.

The same trigger insulator structure is used, and a trigger support extender is used to accommodate the Conflat flange and still leave room for the cooling plumbing.

4. COOLING

Heat dissipation in high pressure spark gaps is known to be significant, and an important task of the design has been the inclusion of a means of cooling in the unit. Energy loss has been the topic of considerable recent investigation by T. Martin and others at SNL, in particular. We have used his results, with the help of L. Rinehart and discussions with T. Martin, to estimate power dissipation in the switch. The Martin estimates, which so far seem to be borne out experiment, predict an energy loss proportional to Vpeak x Ipeak to the power of 1.1846. Extrapolating his curves to the case here, with 100 joules/pulse at 1000 Hz, we have the following result:

Peak voltage, kilovolts	100	100	100	100
Total load + PFN impedance	50	25	10	1.7
Peak current, kiloamps	2	4	10	59
Vpeak X Ipeak, 10Exp9VA	0.2	0.4	1	5.9
Pulse width, nanoseconds	500	250	100	17
Average power, kilowatts	100	100	100	100
Loss, Kilowatts	0.87	2	5.9	48
Loss, Percent	1%	2%	6%	48%

A major unknown factor at this point is the distribution of power dissipation within the spark gap. T. Martin estimates approximately 1/3 of the total dissipation is deposited in the electrodes, the gas, and the outer wall, provided that we avoid conditions with extremely fast rise times. For the geometry of the G610 design we might expect that a significant portion of the gas dissipation also ends up in the electrodes. Altogether we now expect the power distribution to be fairly well distributed over the electrode surfaces, in the flat region of the main gap.

The initial assumption is that the cooling medium is water, and we have considered the case of about 5-6 kW of dissipation as the median design criterion. It is relatively easy to provide enough water to handle the total heat load - 6 kW only needs a flow rate the order of 1 GPM. This is handled easily with 1/4" plumbing channels. Conduction away from the electrode is a more serious problem. To couple the heat into the water requires that heat be conducted to a large portion of the water channel wall area. But even with OFHC copper, the heat conductivity is only 3.9 Watts per cm-degK, so a 1 cm cube of copper can conduct only 390 Watts if the temperature drop is constrained to 100 degK. The dimensions of the electrodes in the vicinity of the trigger are

of the order of only a few cm. After consideration of different water channel shapes, sizes, and locations, the configuration shown in G610 was arrived at. We estimate that the water channels shown can handle up to 2 kW even if the heat is concentrated, and 4-5 kW if there is some spreading by gas expansion and radiation.

More heat may be removed if the coolant is changed. There are several good but often very expensive cooling fluids. The best option that we have found at this time is Polydimethylsiloxane, manufactured by Dow with the name Syltherm XLT. This fluid is chemically inert, has a high electrical resistivity, has a viscosity not too much greater than water. Its density is 0.85, and its specific heat is about 2 J/gram/deg K. The same pumps, heat exchangers, valves, etc. used for water can handle this liquid. At the same time is operating temperature limits are much higher - it can be used at up to 260 deg C. The use of this material should significantly extend the operating power limits.

To provide both cooling and to collect heat dissipation data a fluid cooling system has been designed. Both a diagram and the basic bill of materials is attached. The pump is capable of high flow rate, and the system can be readily extended to higher power by changing the heat exchanger. The insulating portion of the plumbing uses Impolene, a high-temperature, inert, high-resistivity tubing, and the metal parts are all stainless steel. Temperature and flow metering, and flow control, are all included.

5. EXTERNAL CONNECTIONS AND INDUCTANCE

The high internal pressure leads to the use of a relatively small insulator diameter - 1.8 inches on the outside of the gap. A three inch length has been used to give an effective creepage path of a little over three inches, or a little less than 33 kV per inch. It is assumed that the unit will be operated in oil (or some dielectric fluid). A rule of 50 kV/inch maximum surface stress is used.

It is also assumed that a coaxial current return structure is also to be used. If the outer conductor (not shown in the G610 drawing) is 4 inches ID, the average radial stress is of the order of 57 kV/inch, and the maximum stress on the inner cylinder is 197 kV/inch, a high stress, about 20% of the maximum stress on good, clean oil. A concentric barrier sleeve - Mylar, Teflon, or Polycarbonate - around the inner conductor, just inside the main insulator ID, seems called for.

The estimated total inductance of the switch itself is approximately 100 nH, higher than hoped for. 75 to 80%, or about 80 nH, is associated with the main insulator and opposite electrode conductor.

Removing one flute of the inner portion of the insulator might yield 12 nH if this factor should prove critical. A safer alternative would be to remove an inch of the length of the outer portion of the insulator, and about 15 nH. Electric field stress problems on the outside might then be addressed with the use of plastic sleeves and barriers, which may be needed anyway.

6. SPARK GAP PROCESSING AND ASSEMBLY

The required process specifications are given in the attached drawings P-xxx. These include the pump processing procedures. A set of process flow charts specify the appropriate use of the cleaning, plating, assembly, and pump requirements.

A description of the required pump processing station is also appended.

7. TRIGGER GENERATOR

The schematic of the trigger generator is shown in ST610-1.

In order to achieve long-term reliable operation at high repetition rates a hydrogen thyratron is used. The thyratron type chosen is used in excimer and CO2 laser circuits with high charge transfer rates and high peak currents, but, nevertheless, is not capable of switching in less than 20 nanoseconds.

The thyratron is to operate at 20 to 25 kV, with a maximum capability of 32 kV. The step-up transformer will be designed for 1:4 ratio to provide a 100 kV output. The basic design assumes that a faster rise time pulse will be needed, and so a combination of a high-voltage storage cap of 20 pF and a sharpening gap is used at the output. The sharpening gap is also to be built with a high pressure hydrogen fill. This unit will allow fairly easy experimentation with rise rates, trigger voltages, and available energy. A design for such a gap is shown in drawing OV610-01.

The pulse transformer will be a low inductance metglass core unit.

The internal energy storage capacitors total 5 nF, giving an energy of over 1 J/pulse available. At one kHz the unit will provide over 1 kW of trigger power.

The unit provides voltage monitoring, a safety dump and trigger inhibit, external access to a latching safety interlock circuit, and emergency shutdown. The relay logic uses a standard C.C.E. latching relay card.

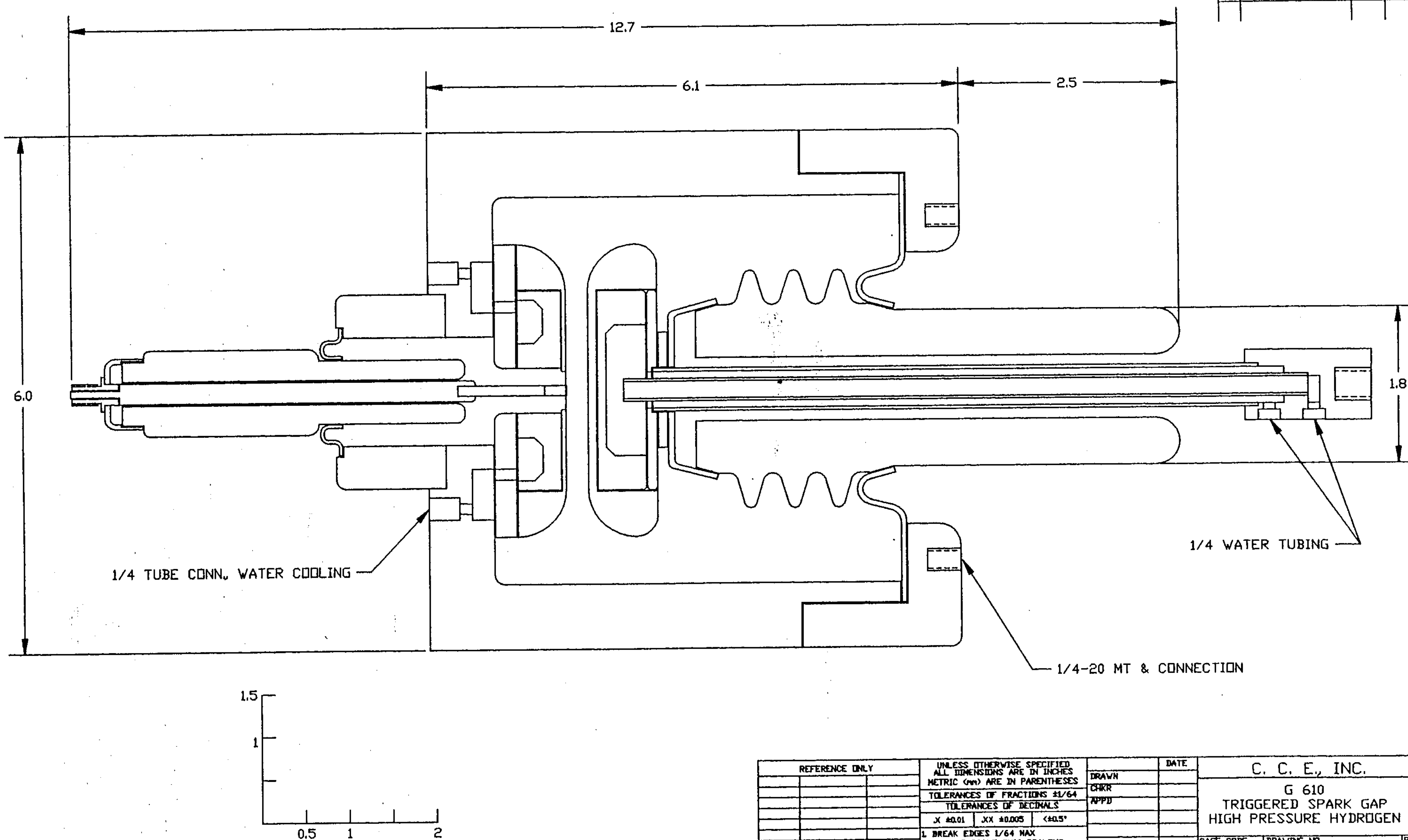
The thyratron driver and driver interlock are shown in drawings ST610-2, -3, -4, -5, and -6.

The power transformer and charging choke will be specified and bought as special purpose items.

The trigger generator is to be built in two sections:

> A rack mounted enclosure will contain the controls, thyratron driver, and high voltage supply. The enclosure panel design is shown in drawings MDT610-20 and -21.
>
> The thyratron, HV PFN caps, pulse transformer, and sharpening gap are to be built in a coaxial housing, which will then bolt directly onto the gap's trigger assembly. This step is taken to provide minimum trigger inductance and maximum rate of rise of trigger voltage. The coax housing diameter will be approximately 4 1/4 inches.

SPARK GAP PARTS



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.X ±0.01 | .XX ±0.005 | ∠±0.5°

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C. C. E., INC.

G 610
TRIGGERED SPARK GAP
HIGH PRESSURE HYDROGEN

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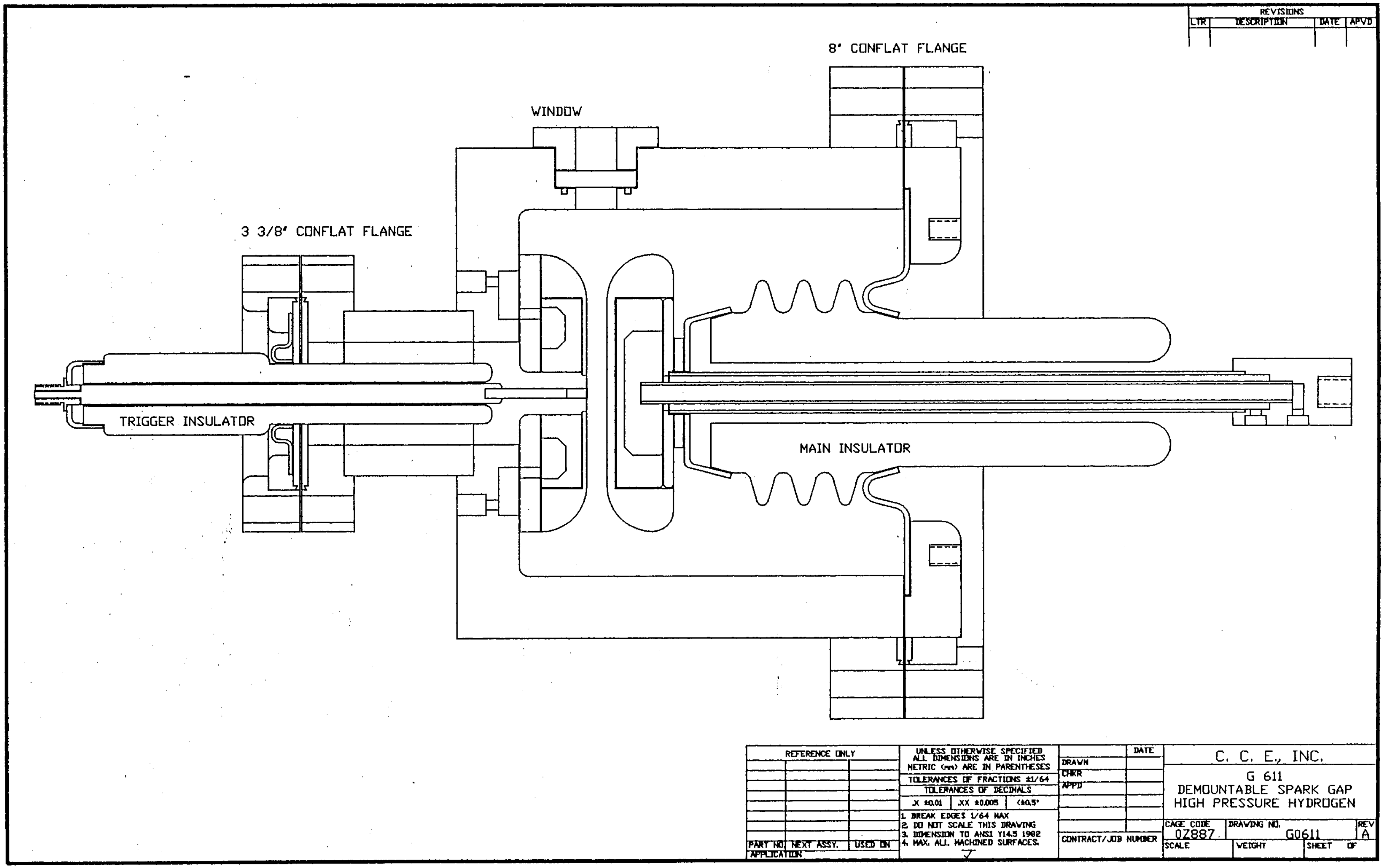
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8' CONFLAT FLANGE
WINDOW
3 3/8' CONFLAT FLANGE
TRIGGER INSULATOR
MAIN INSULATOR
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C. C. E., INC.
G 611
DEMOUNTABLE SPARK GAP
HIGH PRESSURE HYDROGEN
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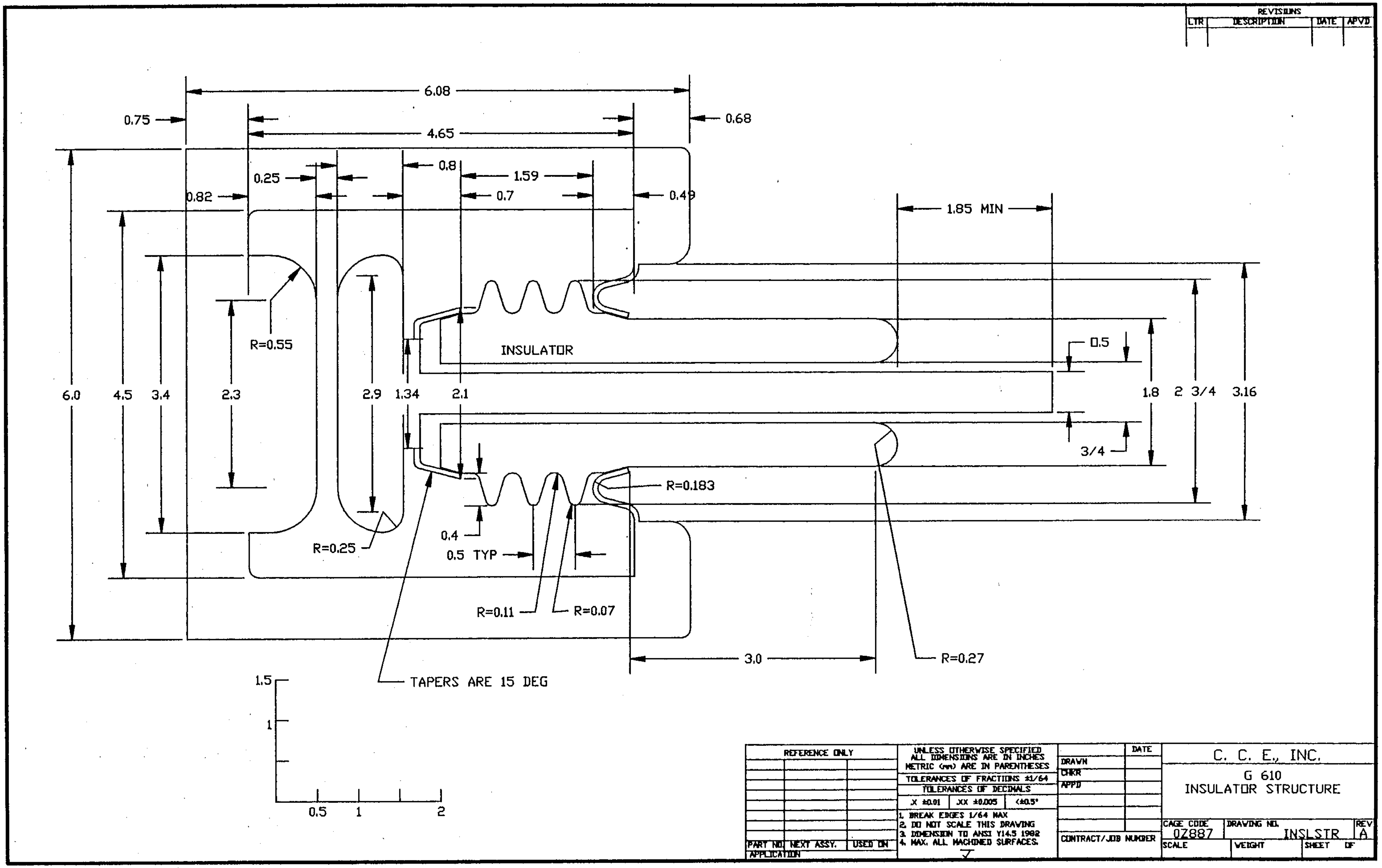

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C. C. E., INC.
G 610
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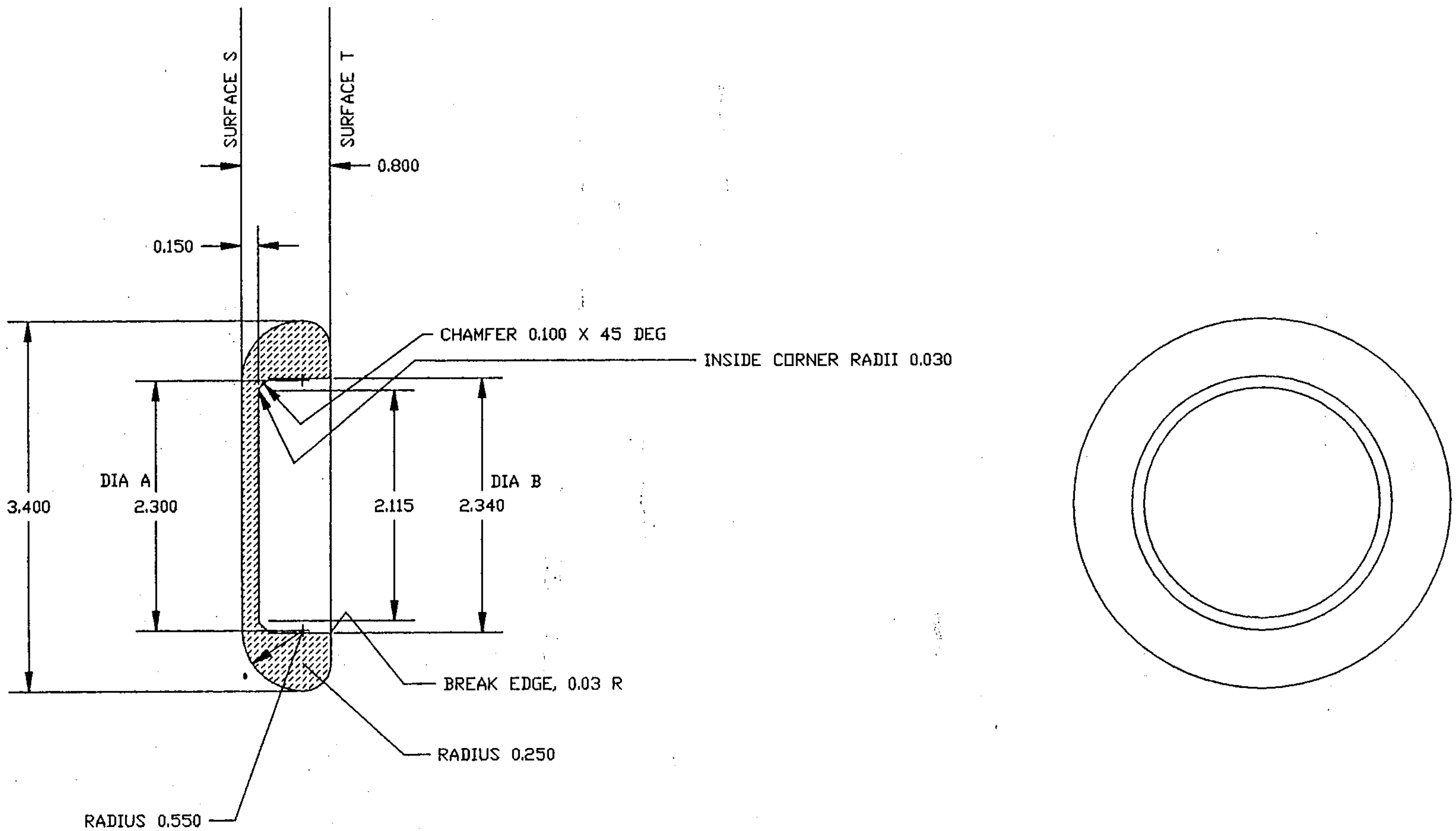

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SURFACES S & T PERPENDICULAR TO DIA B TO 0.005 TIR
RADII TO BLEND SMOOTHLY

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G 610
OPPOSITE MAIN ELECTRODE

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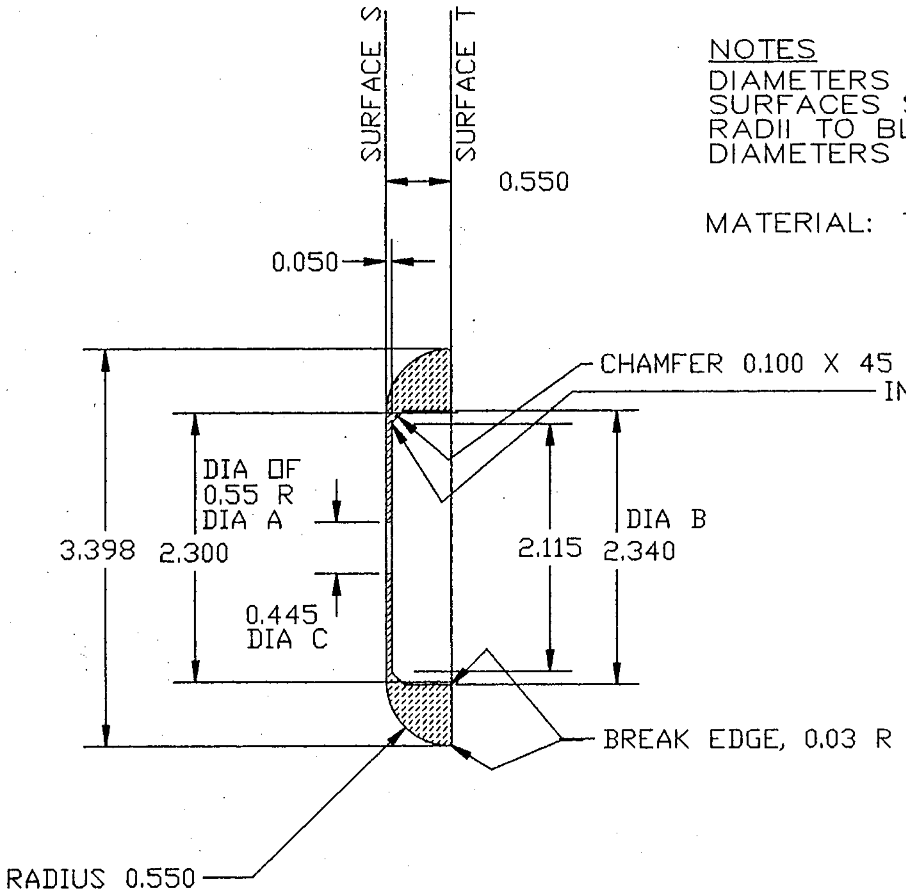

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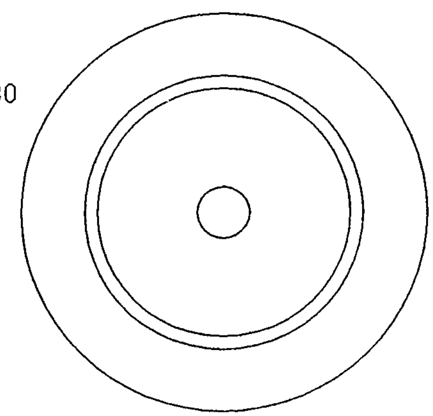

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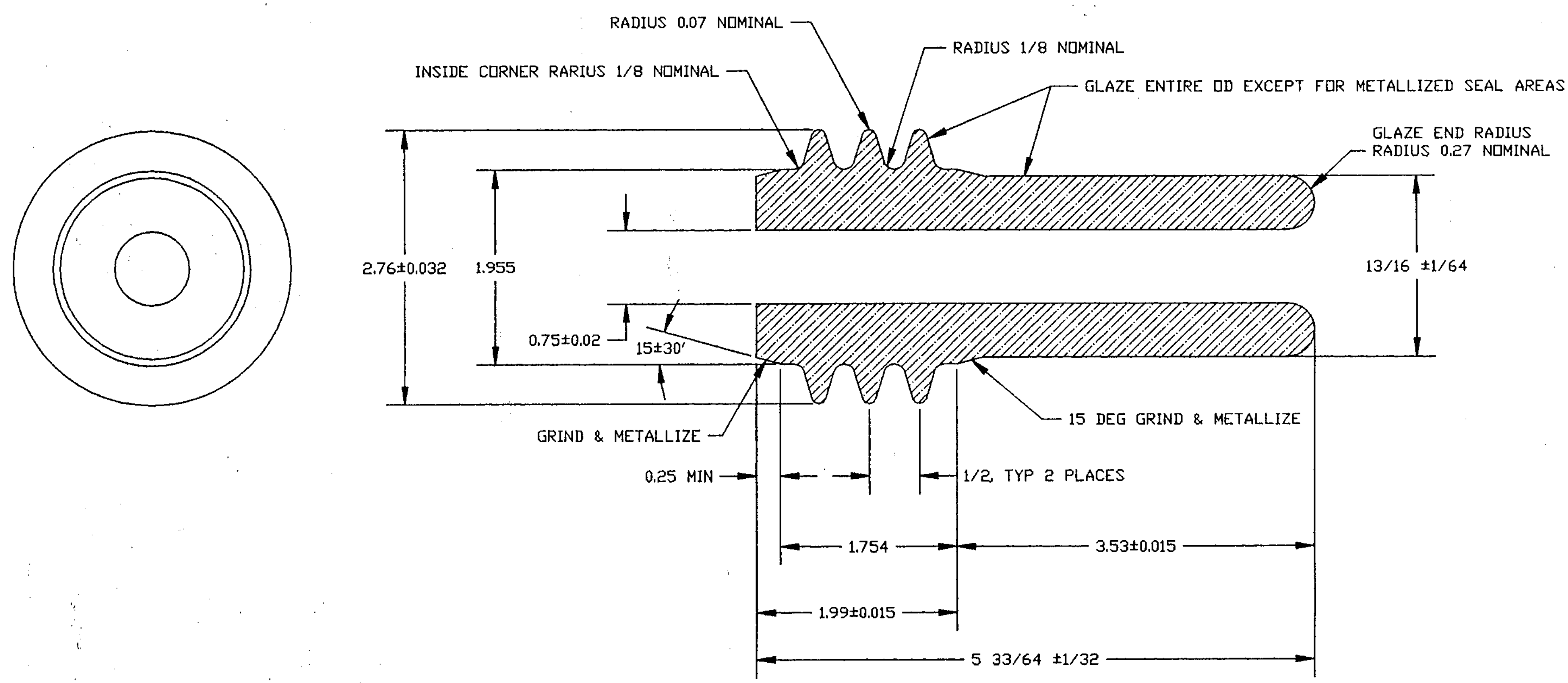

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C. C. E., INC.

G 610
MAIN INSULATOR

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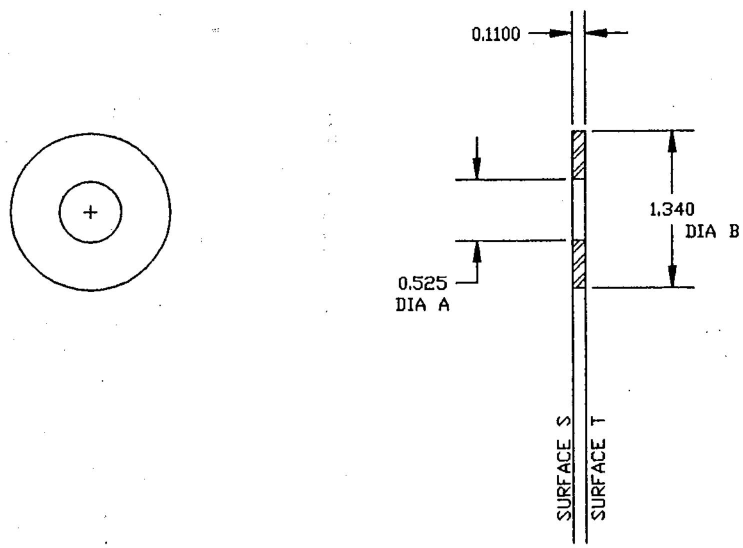

NOTES:
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DIAS A & B CONCENTRIC 0.005 TIR
SURFACE FINISH 32 MICROINCHES MAX
MAXIMUM BURR 0.001

MATERIAL: 304 STAINLESS STEEL

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C. C. E., INC.

G 610
SPACER
OPPOSITE ELECTRODE

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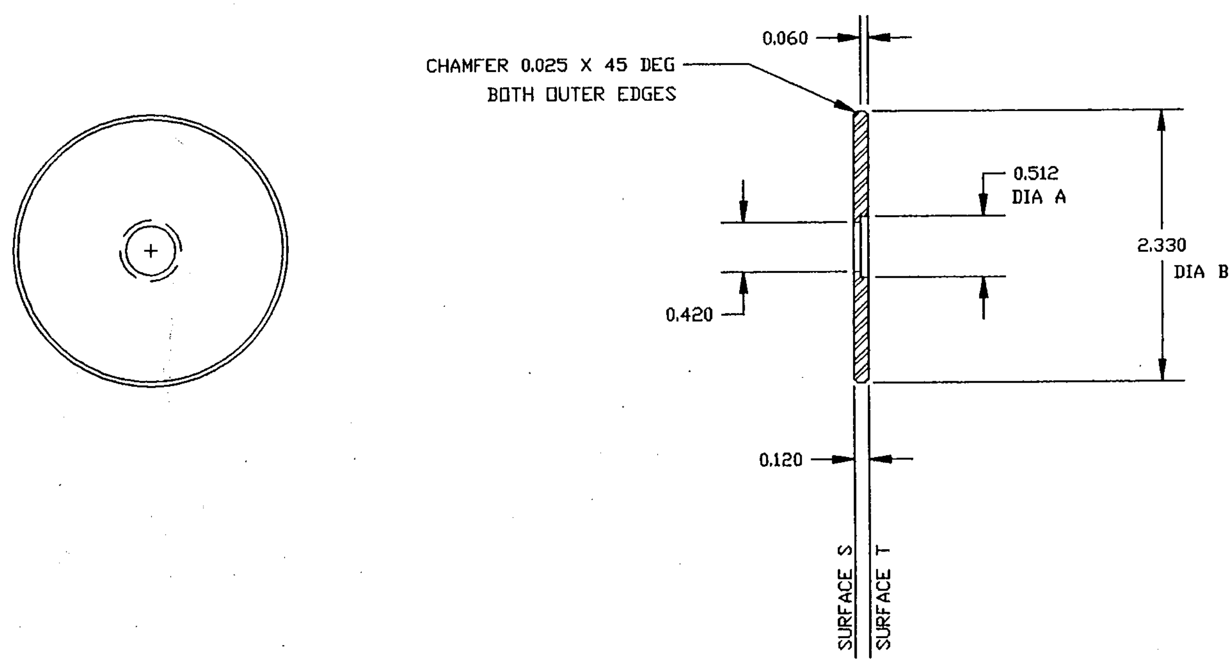

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MATERIAL: 304 STAINLESS STEEL

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C. C. E., INC.

G 610
BACKING PLATE
OPPOSITE ELECT COOLING

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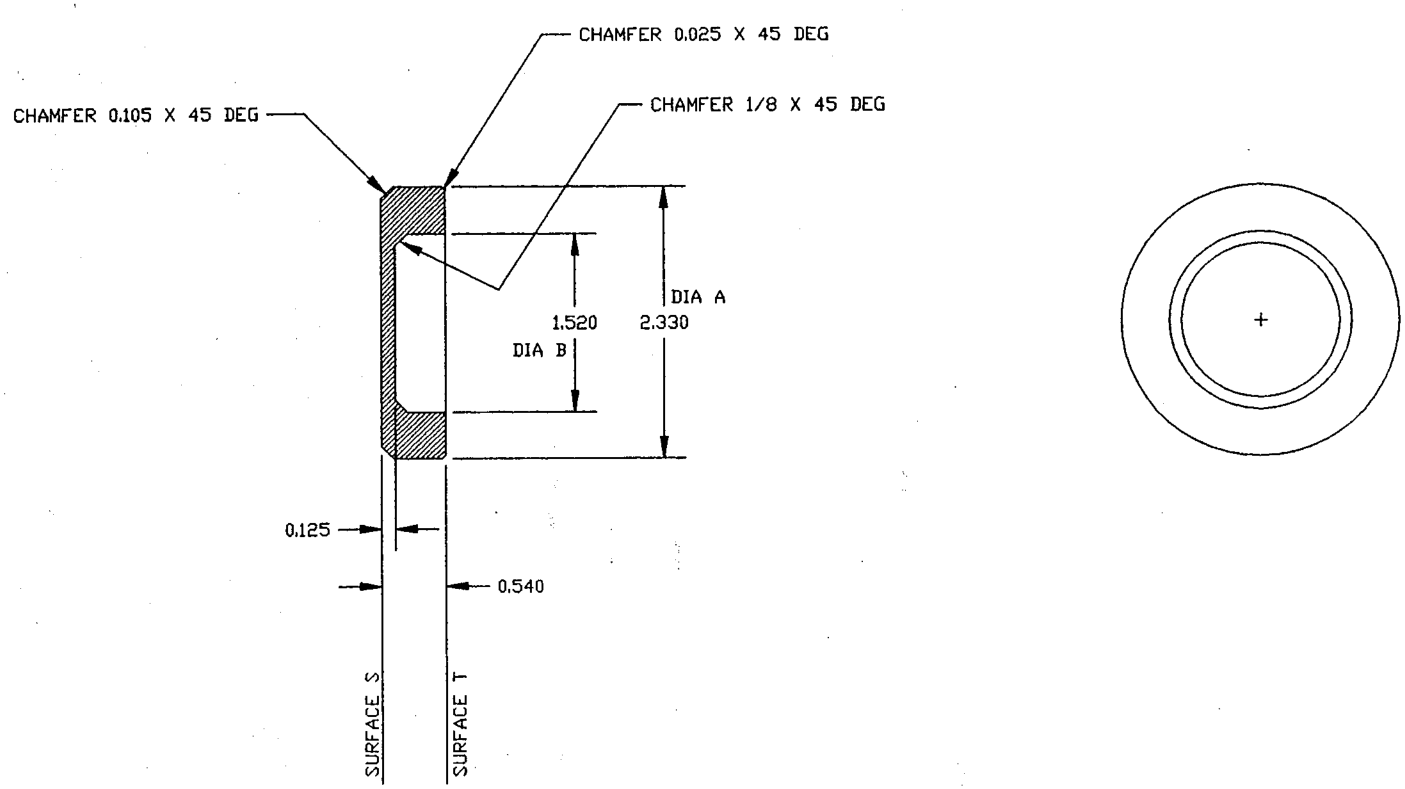
0Z887	G610-006	A
SCALE	WEIGHT	SHEET OF

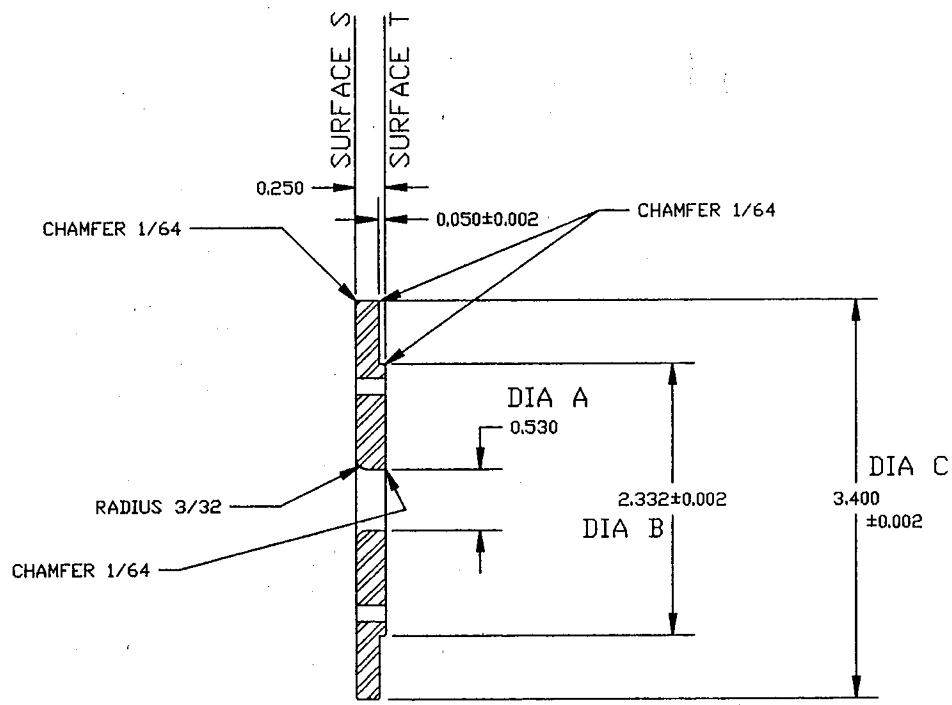


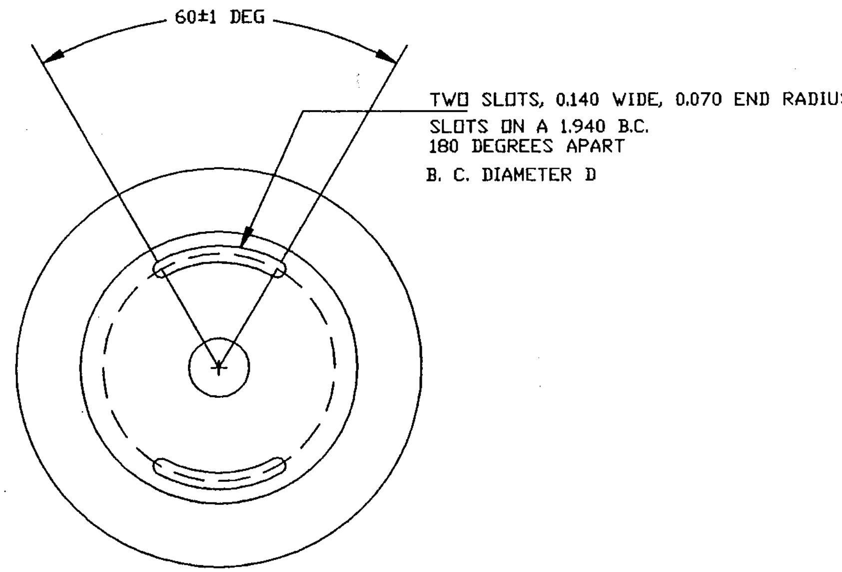
NOTES:
DIAMETERS A & B CONCENTRIC 0.010 TIR MAX
SURFACES S & T PERPENDICULAR TO DIA A TO 0.005 TIR
RADII TO BLEND SMOOTHLY
MAXIMUM BURR 0.001
SURFACE FINISH 32 MICROINCHES MAXIMUM

MATERIAL: OFHC COPPER

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES		DATE	C. C. E., INC.
	TOLERANCES OF FRACTIONS ±1/64	DRAWN		G 610 COOLING CHANNEL OPPOSITE ELECT COOLING
	TOLERANCES OF DECIMALS .X ±0.01 .XX ±0.005 (±0.5°)	CHKR		
	1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.	APPD		CAGE CODE 0Z887 DRAWING NO. G610-007 REV B
PART NO. NEXT ASSY. USED ON APPLICATION		CONTRACT/JOB NUMBER		SCALE WEIGHT SHEET OF





NOTES

DIAMETERS A, B, & D CONCENTRIC 0.005 MAX TIR
SURFACES S & T PERPENDICULAR TO DIA B TO 0.005 TIR
RADII TO BLEND SMOOTHLY
DIAMETERS C & A CONCENTRIC 0.002 MAX TIR
SURFACE FINISH 32 MICROINCHES MAX

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. √

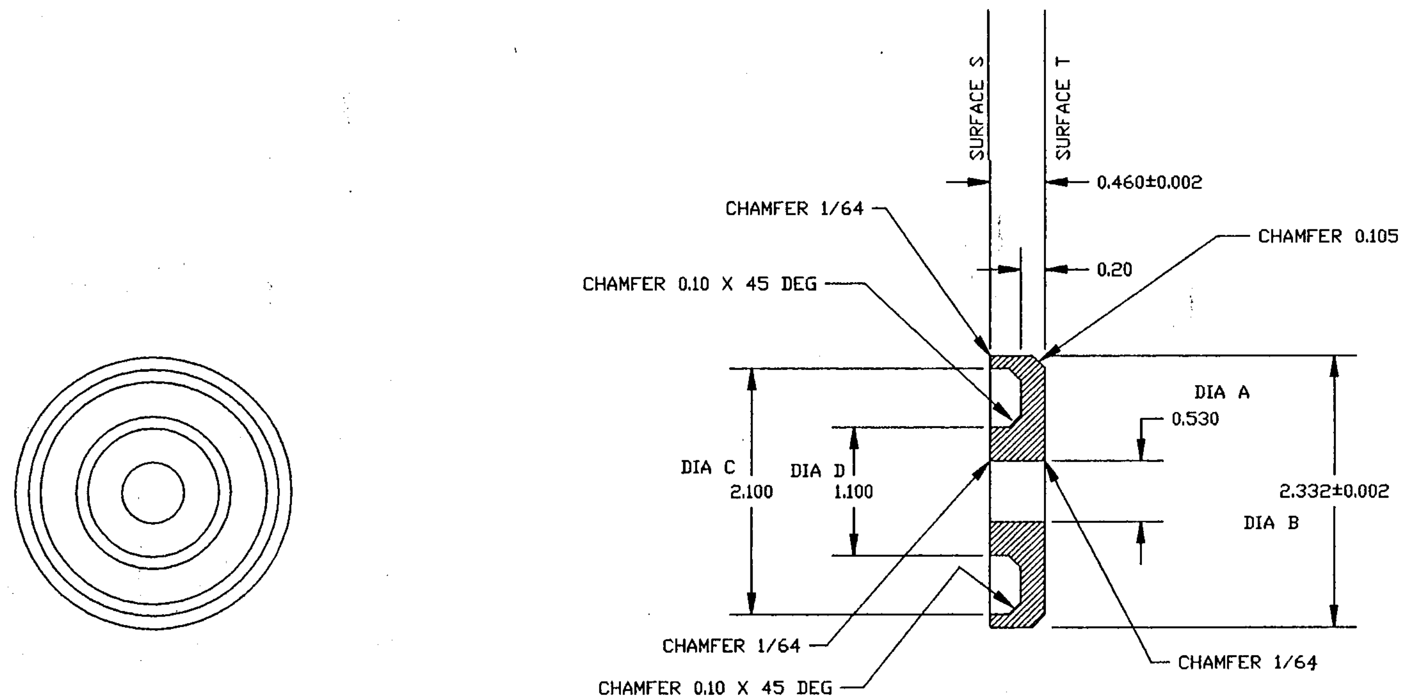
		DATE
DRAWN		
CHKR		
APPD		

CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
ADJ BACKING PLATE
ADJACENT ELECT COOLING

CAGE CODE	DRAWING NO.	REV
0Z887	G610-008	B
SCALE	WEIGHT	SHEET OF



NOTES
DIAMETERS A, B, C, & D CONCENTRIC 0.005 MAX TIR
SURFACES S & T PERPENDICULAR TO DIA B TO 0.005 TIR

SURFACE FINISH 32 MICROINCHES MAX

MATERIAL: OFHC COPPER

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

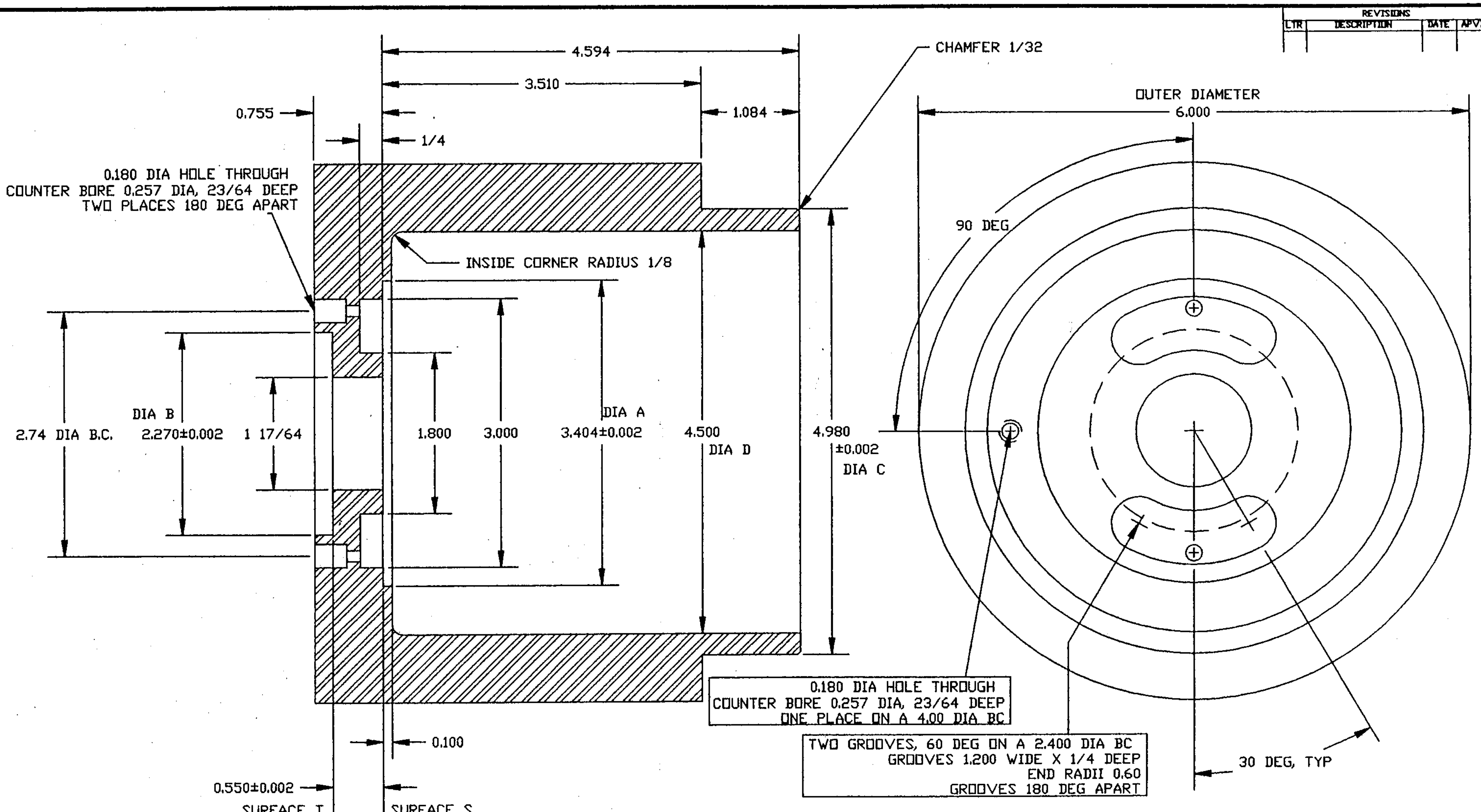
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 .XX ±0.005 ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

PART NO. | NEXT ASSY. | USED ON
APPLICATION

DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER

C. C. E., INC.
G 610
ADJ COOLING CHANNEL
ADJACENT ELECT COOLING

CAGE CODE 0Z887 | DRAWING NO. G610-009 | REV A
SCALE | WEIGHT | SHEET OF



NOTES
DIAMETERS A & B CONCENTRIC 0.002 MAX TIR
SURFACES S & T PERPENDICULAR TO DIA A TO 0.002 TIR
DIAMETERS A, C, & D CONCENTRIC 0.005 MAX TIR
SURFACE FINISH 32 MICROINCHES MAX
BREAK ALL EDGES 0.005

MATERIAL: 304 STAINLESS STEEL

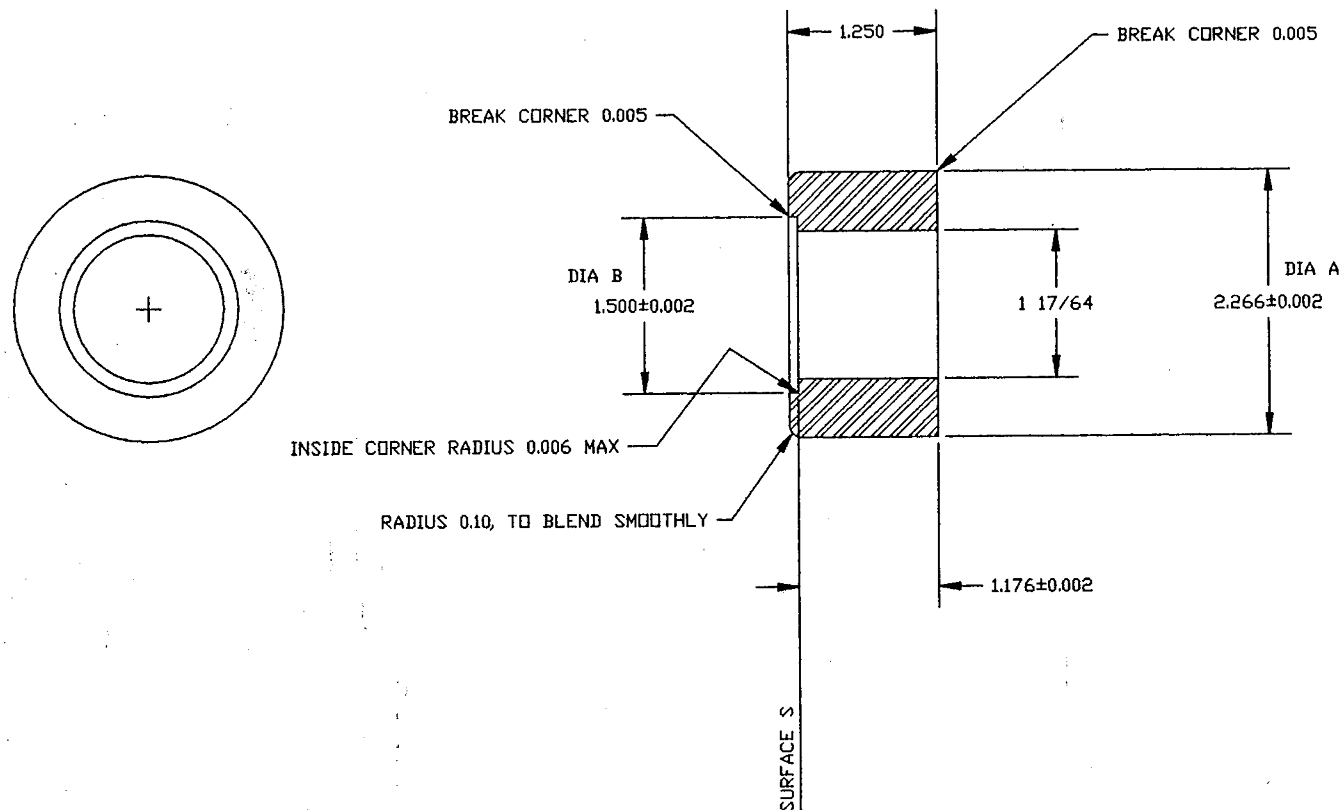
REFERENCE ONLY
PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER

C. C. E., INC.
G 610
ADJ OUTER SHELL
STEEL ENCLOSURE

CAGE CODE 0Z887 | DRAWING NO. G610-010 | REV B
SCALE | WEIGHT | SHEET OF



NOTES:
DIAMETERS A AND B CONCENTRIC 0.002 TIR
SURFACE S FLAT AND PERPENDICULAR TO DIA A 0.002 TIR
SURFACE FINISH 32 MICROINCHES

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		

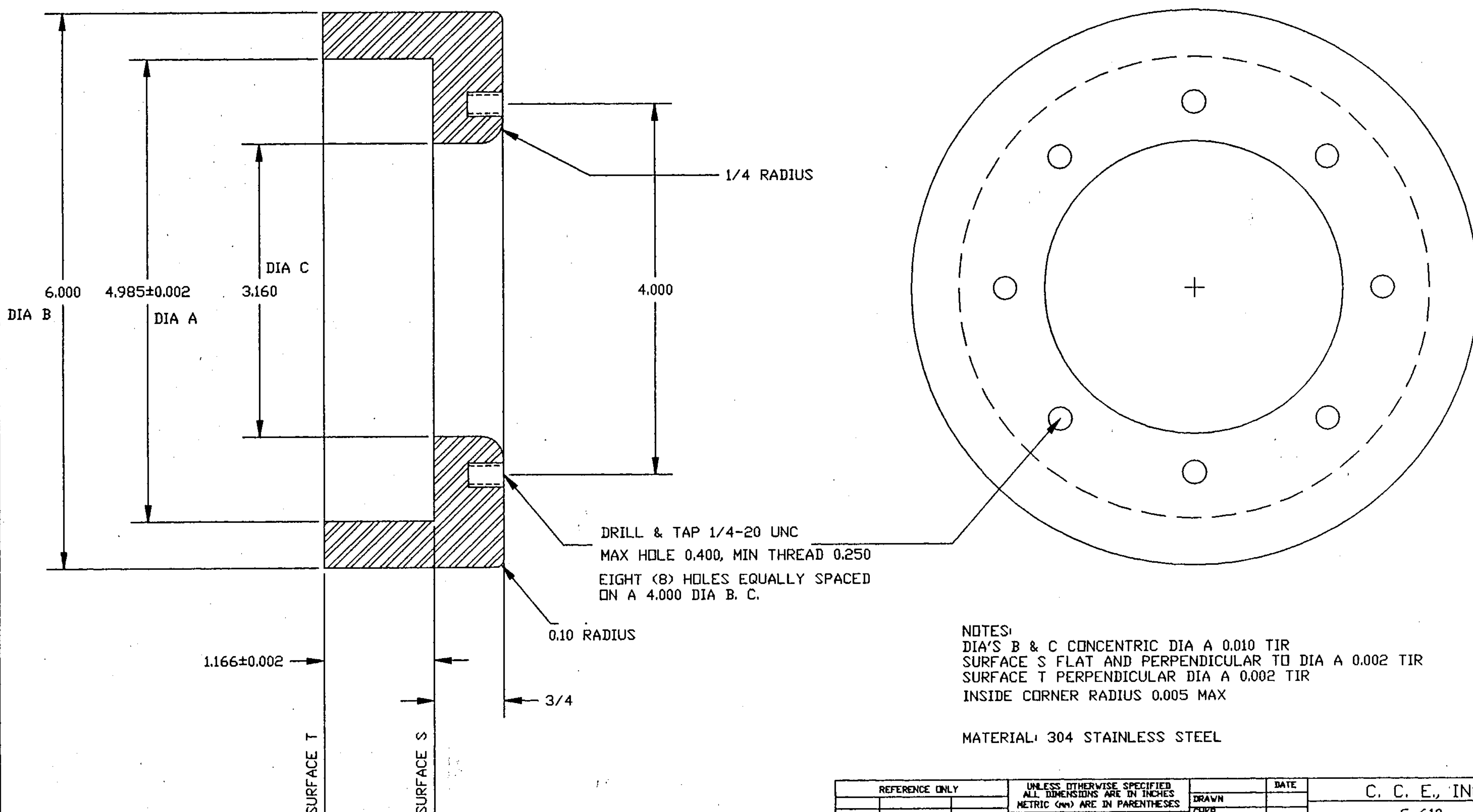
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
TRIGGER ASSEM SPACER

CAGE CODE	DRAWING NO.	REV
0Z887	G610-011	B

SCALE	WEIGHT	SHEET OF



NOTES:
DIA'S B & C CONCENTRIC DIA A 0.010 TIR
SURFACE S FLAT AND PERPENDICULAR TO DIA A 0.002 TIR
SURFACE T PERPENDICULAR DIA A 0.002 TIR
INSIDE CORNER RADIUS 0.005 MAX

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

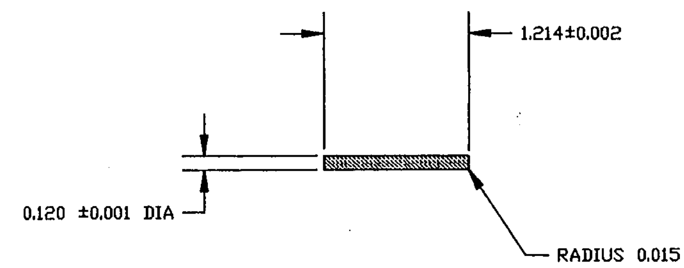
	DATE
DRAWN	
CHKR	
APPD	
CONTRACT/JOB NUMBER	

C. C. E., INC.

G 610
END PLATE
MAIN INSL ASSEM

CAGE CODE	DRAWING NO.	REV
0Z887	G610-012	B
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



MATERIAL: TUNGSTEN + 3% RHENIUM, PLANSEE W3Re OR EQUIVALENT, 0.120 ROD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

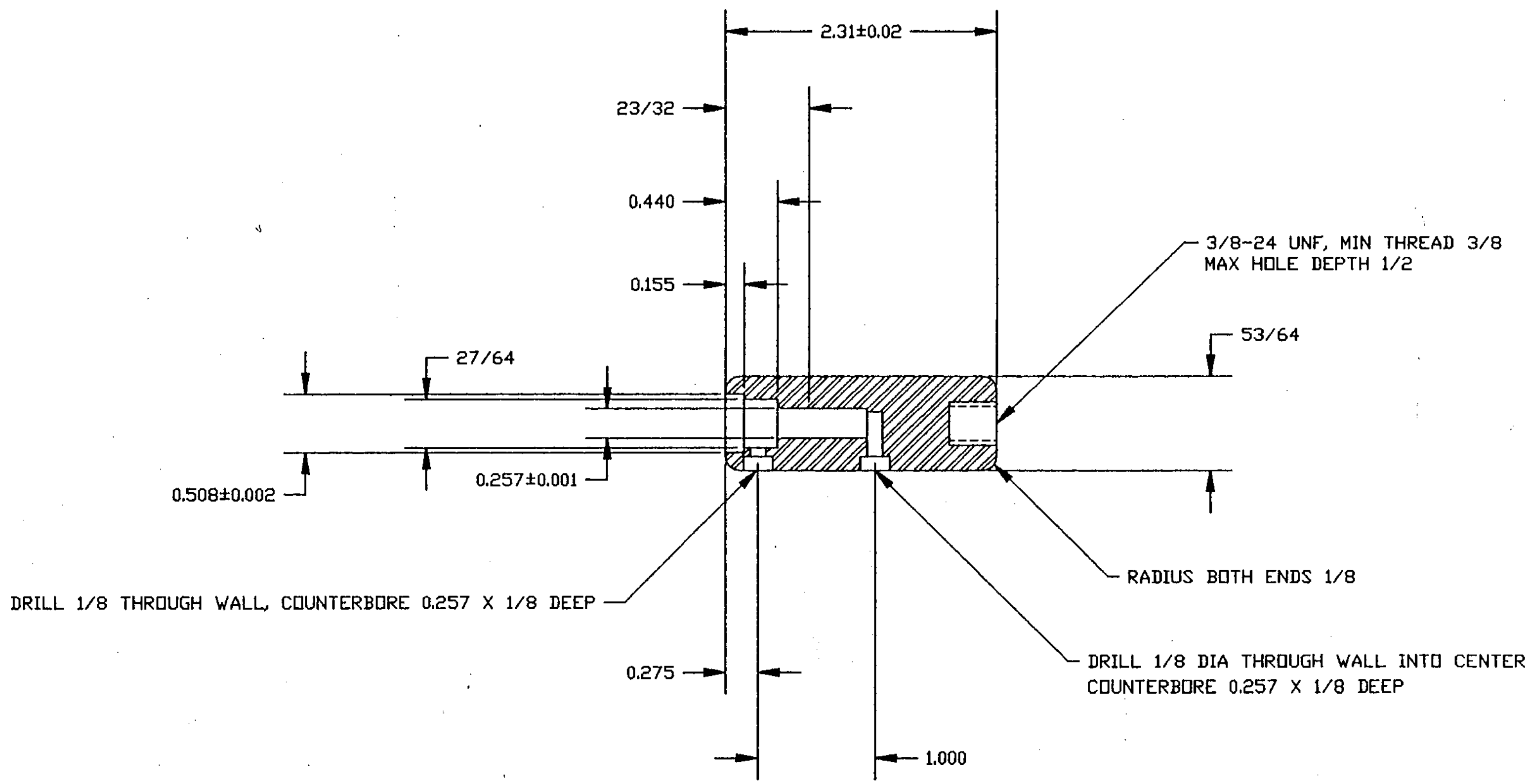
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
TRIGGER PIN

CAGE CODE	DRAWING NO.	REV
0Z887	G610-013	A
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



MATERIAL: 304 STAINLESS STEEL

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | (±0.5°)

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

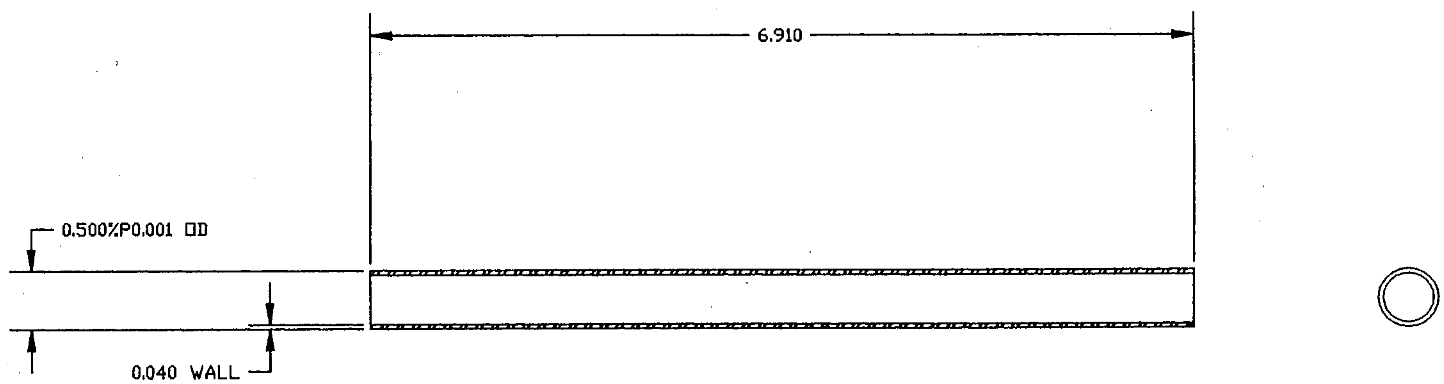
	DATE
DRAWN	
CHKR	
APPD	

CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
WATER CONNECTOR

CAGE CODE	DRAWING NO.		REV
0Z887	G610-014		B
SCALE	WEIGHT	SHEET OF	



MATERIAL: 304 STAINLESS STEEL

REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		

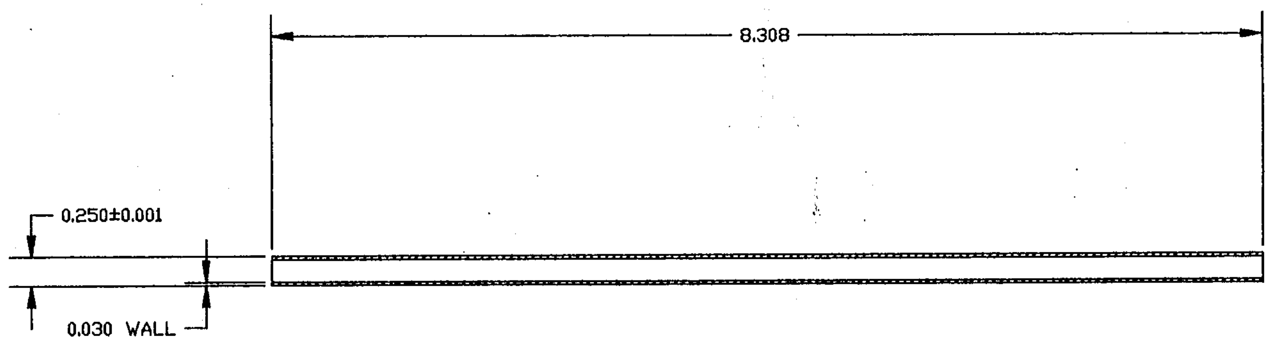
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
OUTER WATER TUBE
ASSEM A610-007

CAGE CODE 0Z887 | DRAWING NO. G610-015 | REV A

SCALE | WEIGHT | SHEET OF



MATERIAL: 304 STAINLESS STEEL

REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 .XX ±0.005 ∠±0.5°

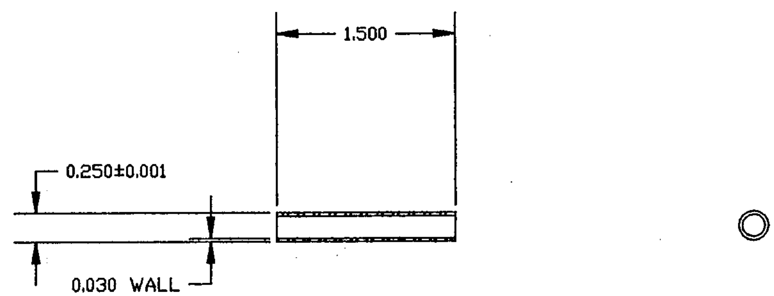
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 610
INNER WATER TUBE
ASSEM. A610-007

CAGE CODE	DRAWING NO.	REV
0Z887	G610-016	A
SCALE	WEIGHT	SHEET OF



MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		

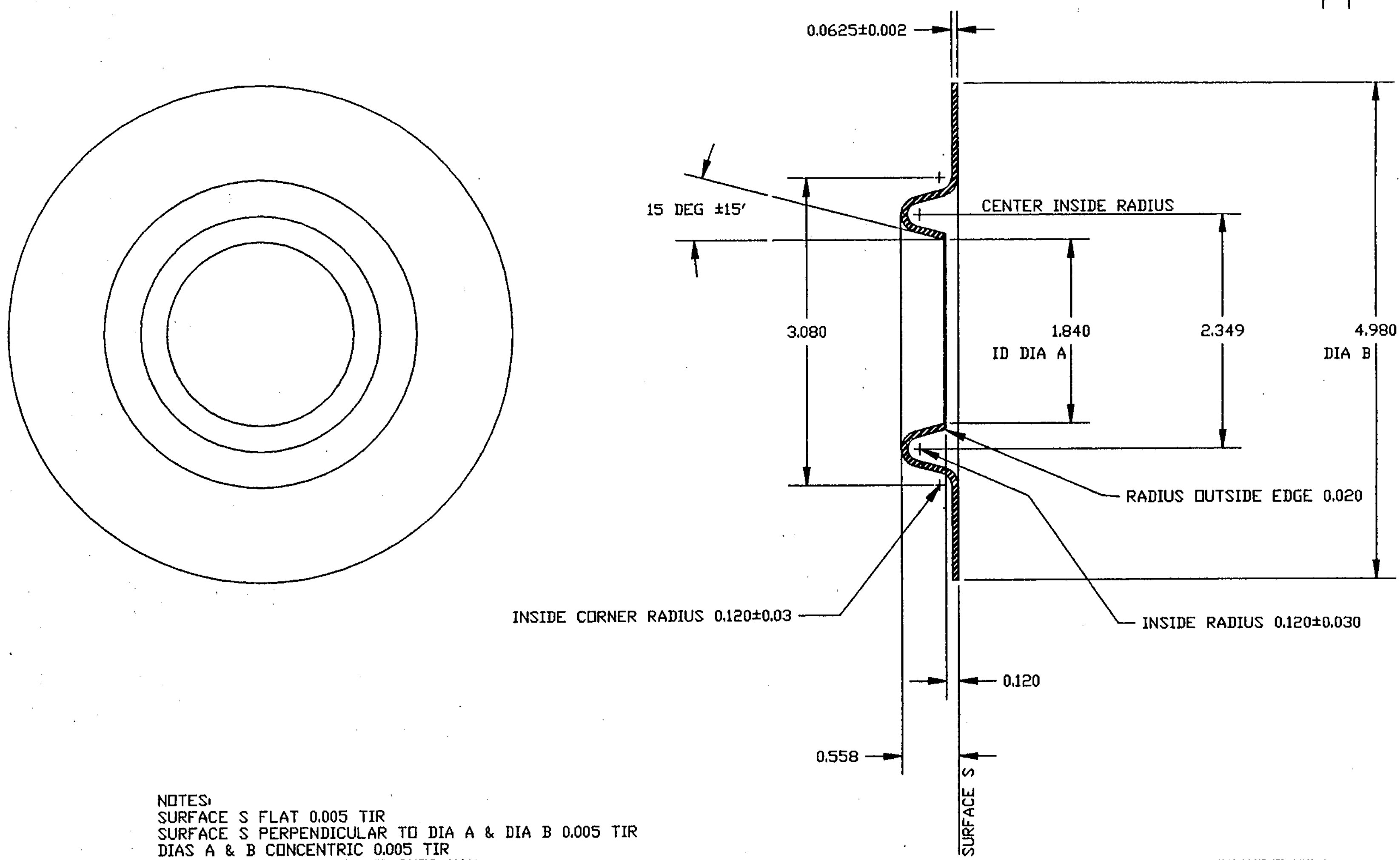
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
ADJACENT WATER TUBE
ASSEM. A610-005

CAGE CODE	DRAWING NO.	REV
0Z887	G610-017	A
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



NOTES:
SURFACE S FLAT 0.005 TIR
SURFACE S PERPENDICULAR TO DIA A & DIA B 0.005 TIR
DIAS A & B CONCENTRIC 0.005 TIR
SURFACE FINISH 32 MICROINCHES MAX
MAXIMUM BURR 0.001

MATERIAL: 42% NICKEL - BALANCE IRON
THICKNESS: 0.0625 ±0.002

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

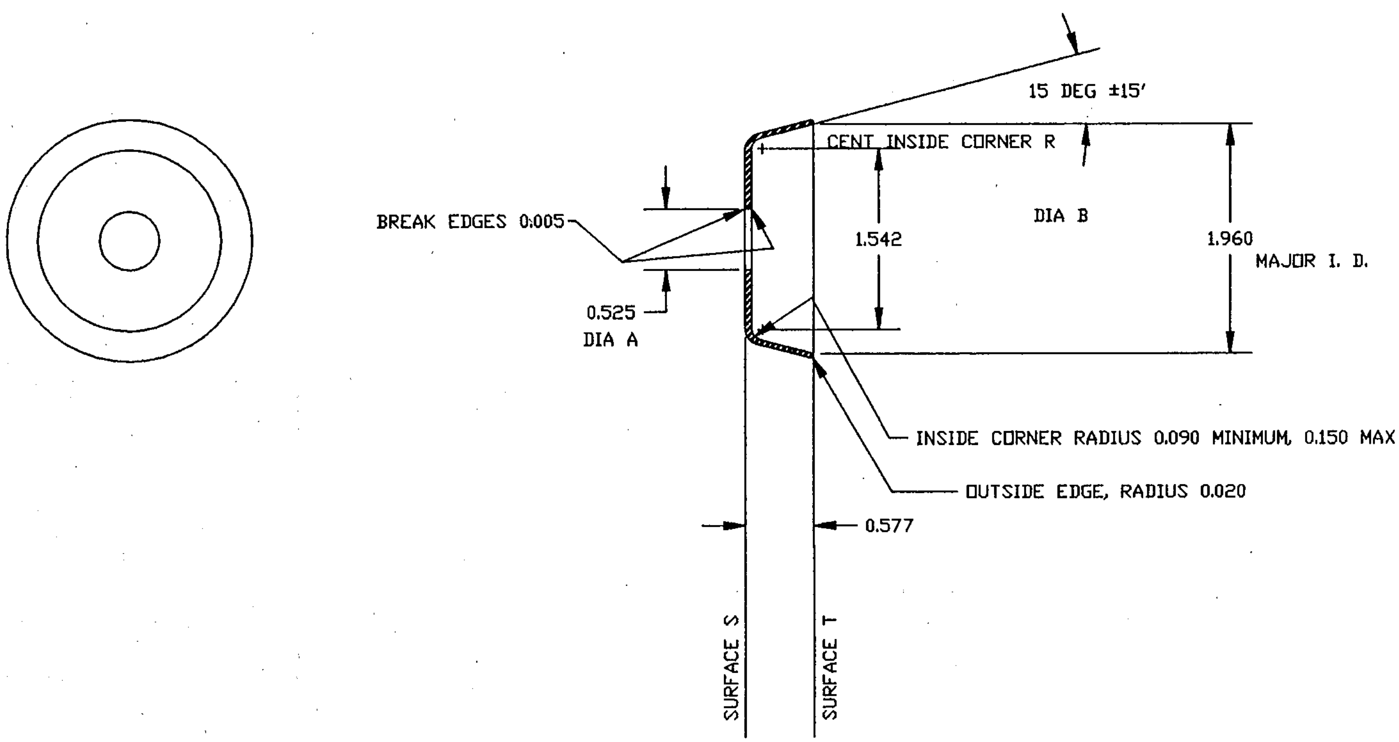
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

DRAWN | DATE
CHKR
APPD
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
SEAL FLANGE
MAIN INSULATOR

CAGE CODE	DRAWING NO.	REV
0Z887	G610-042	A
SCALE	WEIGHT	SHEET OF



NOTES:
SURFACE S FLAT 0.005 TIR
SURFACE S PERPENDICULAR TO DIA A & DIA B 0.005 TIR
DIAS A & B CONCENTRIC 0.005 TIR
SURFACE FINISH 32 MICROINCHES MAX
MAXIMUM BURR 0.001

MATERIAL: 42% NICKEL - BALANCE IRON
THICKNESS: 0.0625 ±0.002

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

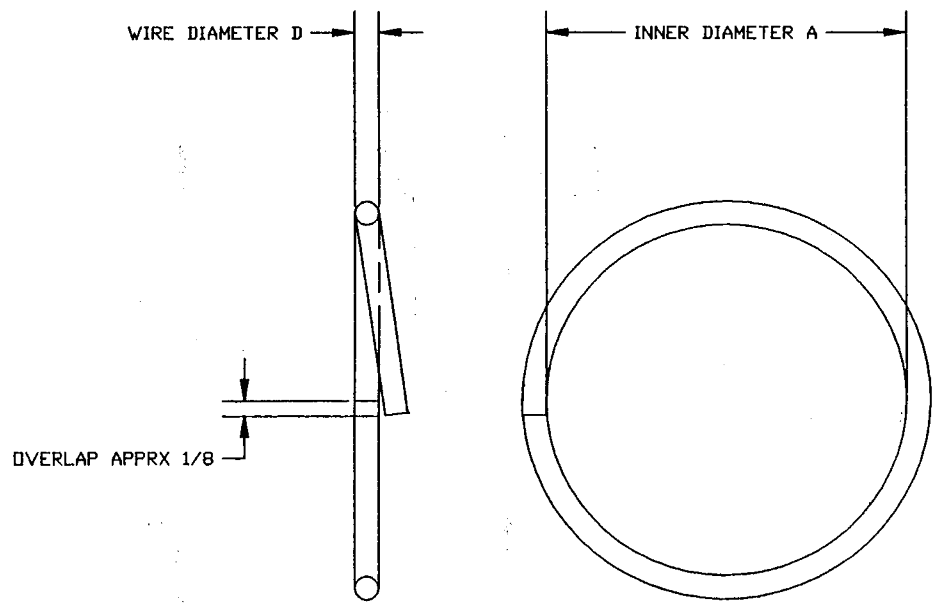
REFERENCE ONLY	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES		DATE
	TOLERANCES OF FRACTIONS ±1/64	DRAWN	
	TOLERANCES OF DECIMALS	CHKR	
	.X ±0.01 .XX ±0.005 (±0.5°)	APPD	
	1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.		
PART NO. NEXT ASSY. USED ON APPLICATION		CONTRACT/JOB NUMBER	

C. C. E., INC.

G 610
SEAL CUP
OPPOSITE ELECTRODE

CAGE CODE	DRAWING NO.	REV
0Z887	G610-041	A
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



DASH #	DIA A	WIRE D	MATERIAL	LIQ/SOLID DEG C
001	2 17/64	1/32	OFHC COPPER	1083/1083
002	3 25/64	1/32	OFHC COPPER	1083/1083
003	1/2	1/32	PALCUSIL 15	900/850
004	1/2	1/32	OFHC COPPER	1083/1083
005	1/4	1/32	OFHC COPPER	1083/1083
006	1/8	1/32	PALCUSIL 15	900/850
007	1/4	1/32	PALCUSIL 15	900/850

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

DRAWN | CHKR | APPD | DATE

CONTRACT/JOB NUMBER

C. C. E., INC.

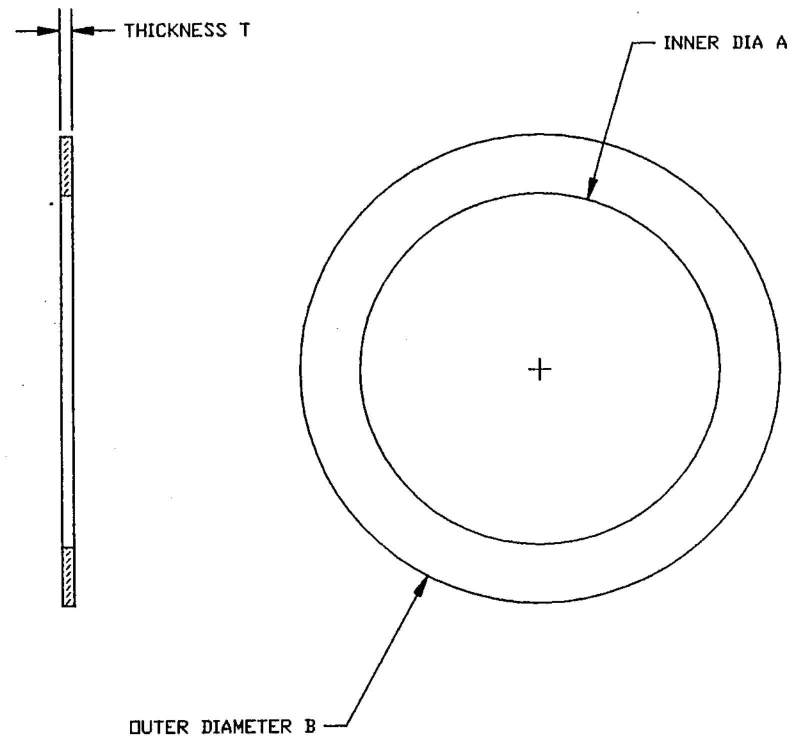
G 610
SOLDER/BRAZE RINGS

CAGE CODE 0Z887 | DRAWING NO. B6-1 | REV A

SCALE | WEIGHT | SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

DASH #	DIA A INNER DIA	DIA B OUTER DIA	THICKNESS T	MATERIAL	LIQ/SOLID DEG C
001	1 17/64	2 1/4	0.003	OFHC COPPER	1083/1083
002	1 17/64	1.80	0.003	OFHC COPPER	1083/1083
003	3.00	3 25/64	0.003	OFHC COPPER	1083/1083
004	17/32	1 11/32	0.003	PALCUSIL 15	900/850
005	1/2	1 11/32	0.003	PALCUSIL 15	900/850
006	1 17/32	2 21/64	0.003	PALCUSIL 15	900/850
007	ZERO	2 1/8	0.003	PALCUSIL 15	900/850
008	3.0	4 63/64	0.003	PALCUSIL 15	900/850
009	33/64	2 1/8	0.003	PALCUSIL 15	900/850
010	17/32	1 7/64	0.003	PALCUSIL 15	900/850
011	2 7/64	2 21/64	0.003	PALCUSIL 15	900/850
012	2 11/32	3 13/32	0.003	PALCUSIL 15	900/850
013	5.00	6.00	0.003	CUSIL	780/780
014	4.50	4 31/32	0.003	CUSIL	780/780
015	1 17/64	1 31/64	0.003	PALCUSIL 15	900/850



REFERENCE ONLY

PART NO | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

CONTRACT/JOB NUMBER

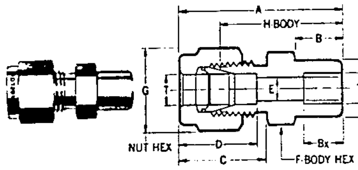
C. C. E., INC.

G 610
SOLDER WASHERS

CAGE CODE	DRAWING NO.	REV
0Z887	B6-2	A
SCALE	WEIGHT	SHEET OF

SWAGELOK to Tube Socket Weld Union

DIMENSIONS —
A-C-D are typical finger-tight.
F-G are across hex flats.

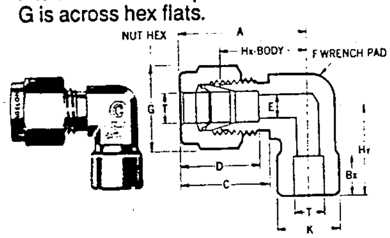


CONNECTS TUBES

T Tube O.D.	CATALOG NUMBER	A	B	Bx	C	D	E Minimum Opening	F	G	H	J
1/8	-200-6-2W	1.14	.34	.25	.60	.50	.09	7/16	7/16	.88	.31
1/4	-400-6-4W	1.32	.41	.31	.70	.60	.19	1/2	9/16	1.03	.44
3/8	-600-6-6W	1.48	.47	.38	.76	.66	.28	5/8	11/16	1.19	.62
1/2	-810-6-8W	1.62	.47	.50	.86	.90	.41	13/16	7/8	1.22	.75
3/4	-1210-6-12W	1.71	.47	.56	.86	.96	.62	1 1/16	1 1/8	1.31	1.05
1	-1610-6-16W	2.07	.56	.75	1.04	1.23	.88	1 3/8	1 1/2	1.59	1.31

SWAGELOK to Tube Socket Weld Elbow

DIMENSIONS —
A-C-D are typical finger-tight.
F is across wrench pads.
G is across hex flats.

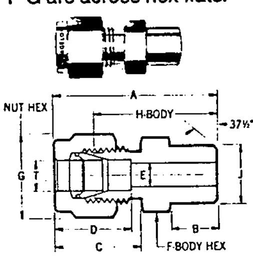


CONNECTS TUBES

T Tube O.D.	CATALOG NUMBER	A	A_1	Bx	C	D	E Minimum Opening	F	F_1	G	Hx	Hx_1	Hy	Hy_1	K	K_1
1/4	-400-9-4W†	1.06	1.01	.31	.70	.60	.19	1/2	7/16	9/16	.77	.72	.77	.72	.50	.50
3/8	-600-9-6W†	1.20	1.13	.38	.76	.66	.28	5/8	1/2	11/16	.91	.84	.91	.84	.62	.62
1/2	-810-9-8W†	1.42	1.37	.50	.86	.90	.41	13/16	11/16	7/8	1.02	.97	1.02	.97	.81	.81

SWAGELOK to Male Pipe Weld Connector

DIMENSIONS —
A-C-D are typical finger-tight.
F-G are across hex flats.



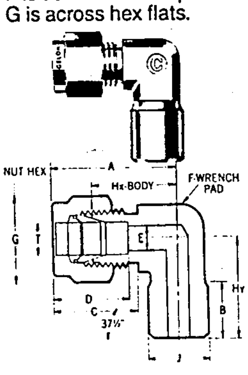
CONNECTS TUBE TO PIPE

T Tube O.D.	Male Pipe Weld Size	CATALOG NUMBER	A	B	C	D	E Minimum Opening	F	G	H	J
1/8	1/8	-200-1-2W	1.20	.38	.60	.50	.09*	7/16	7/16	.94	.405
3/16	1/8	-300-1-2W	1.23	.38	.63	.54	.12*	7/16	1/2	.97	.405
1/4	1/8	-400-1-2W	1.29	.38	.70	.60	.19	1/2	9/16	1.00	.405
1/4	1/4	-400-1-4W	1.49	.56	.70	.60	.19*	9/16	9/16	1.20	.540
5/16	1/8	-500-1-2W	1.34	.38	.73	.64	.20	9/16	5/8	1.05	.405
5/16	1/4	-500-1-4W	1.52	.56	.73	.64	.25	9/16	5/8	1.23	.540
3/8	1/4	-600-1-4W	1.57	.56	.76	.66	.28	5/8	11/16	1.28	.540
3/8	3/8	-600-1-6W	1.57	.56	.76	.66	.28*	11/16	11/16	1.28	.675
3/8	1/2	-600-1-8W	1.82	.75	.76	.66	.28*	7/8	11/16	1.53	.840
1/2	3/8	-810-1-6W	1.71	.56	.86	.90	.41	13/16	7/8	1.31	.675
1/2	1/2	-810-1-8W	1.93	.75	.86	.90	.41*	7/8	7/8	1.53	.840
1/2	3/4	-810-1-12W	1.99	.75	.86	.90	.41*	1 1/16	7/8	1.59	1.050
5/8	1/2	-1010-1-8W	1.93	.75	.86	.96	.50	15/16	1	1.53	.840
3/4	3/4	-1210-1-12W	1.99	.75	.86	.96	.62*	1 1/16	1 1/8	1.59	1.050
1	1	-1610-1-16W	2.45	.94	1.04	1.23	.88*	1 3/8	1 1/2	1.97	1.315

For tube O.D. sizes 1-1/4", 1-1/2" and 2", see *Tube Fittings Over 1"* subsection in your Master Catalog Binder.

SWAGELOK to Male Pipe Weld Elbow

DIMENSIONS —
A-C-D are typical finger-tight.
F is across wrench pads.
G is across hex flats.



CONNECTS TUBE TO PIPE

T Tube O.D.	Male Pipe Weld Size	CATALOG NUMBER	A	A_1	B	C	D	E Minimum Opening	F	F_1	G	Hx	Hx_1	Hy	Hy_1	J
1/4	1/8	-400-2-2W†	1.06	1.01	.38	.70	.60	.19*	1/2	7/16	9/16	.77	.72	.74	.75	.405
1/4	1/4	-400-2-4W	1.06	1.07	.56	.70	.60	.19*	1/2	1/2	9/16	.77	.78	.92	.94	.540
3/8	1/4	-600-2-4W†	1.20	1.13	.56	.76	.66	.28	5/8	1/2	11/16	.91	.84	1.00	1.00	.540
1/2	1/2	-810-2-8W	1.42	1.43	.75	.86	.90	.41*	13/16	13/16	7/8	1.02	1.03	1.30	1.38	.840
3/4	3/4	-1210-2-12W†	1.57	1.56	.75	.86	.96	.62*	1 1/16	1	1 1/8	1.17	1.16	1.45	1.50	1.050

* "E" dimension is minimum opening. Fittings of this group are back-drilled to larger I.D. at pipe weld end.

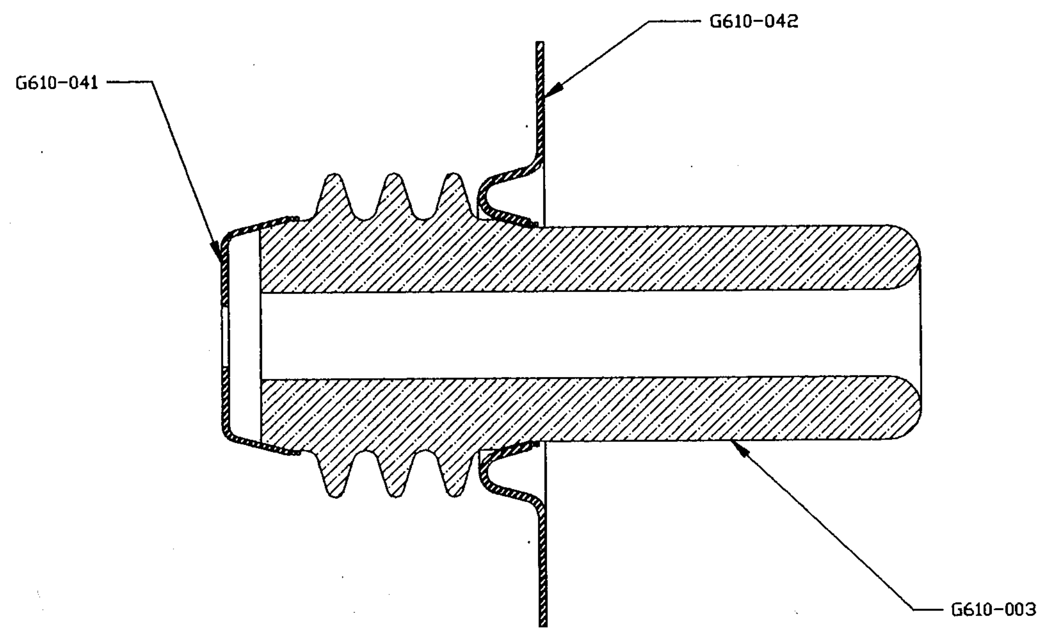
For more information on weld fittings, see *Weld Fittings* subsection in your Master Catalog Binder.

All dimensions are in inches. Dimensions for reference only, subject to change.

DIMENSIONS — A_1 - F_1 - Hx_1 - Hy_1 — K_1 are for brass and aluminum only / † Brass and aluminum fittings marked thus are not gageable.

When ordering, be sure to specify material. See pages 6 and 7 for complete ordering information.

SPARK GAP ASSEMBLIES



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

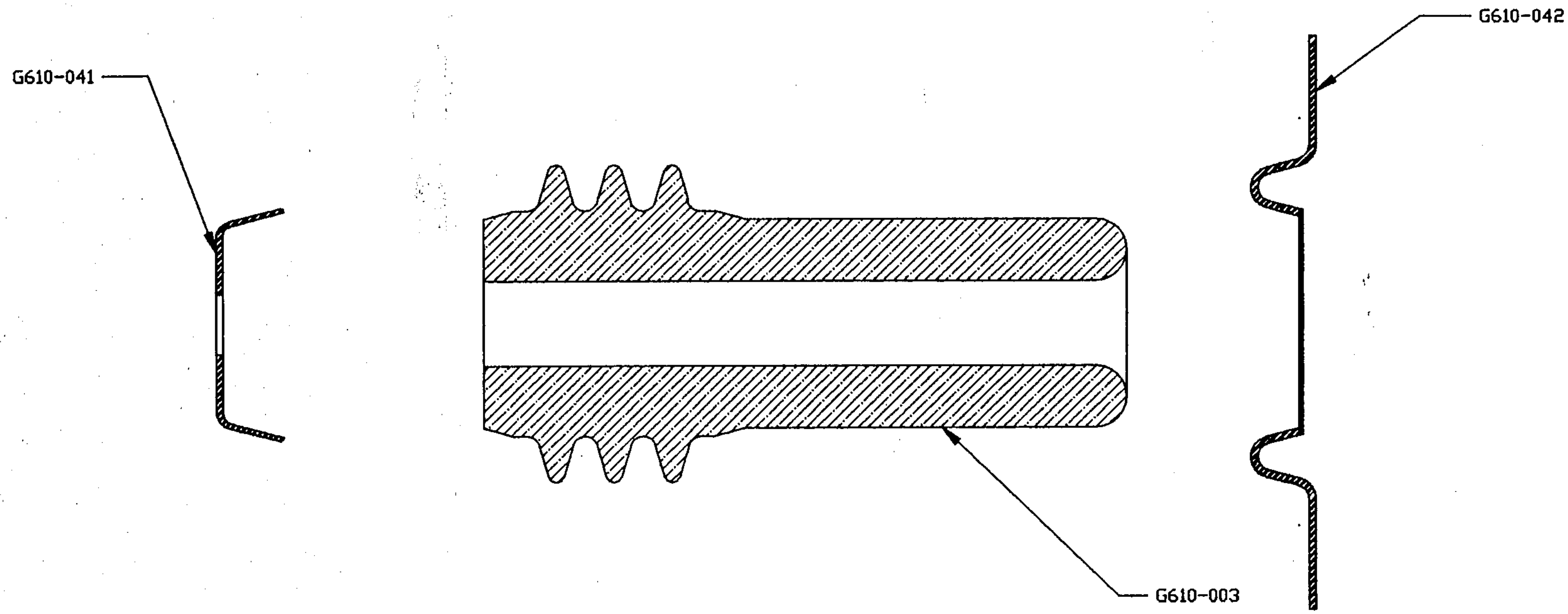
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	
CONTRACT/JOB NUMBER	

C. C. E., INC.

G 610
HV INSULATOR ASSEMBLY

CAGE CODE	DRAWING NO.	REV
0Z887	A610-001	A
SCALE	WEIGHT	SHEET OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

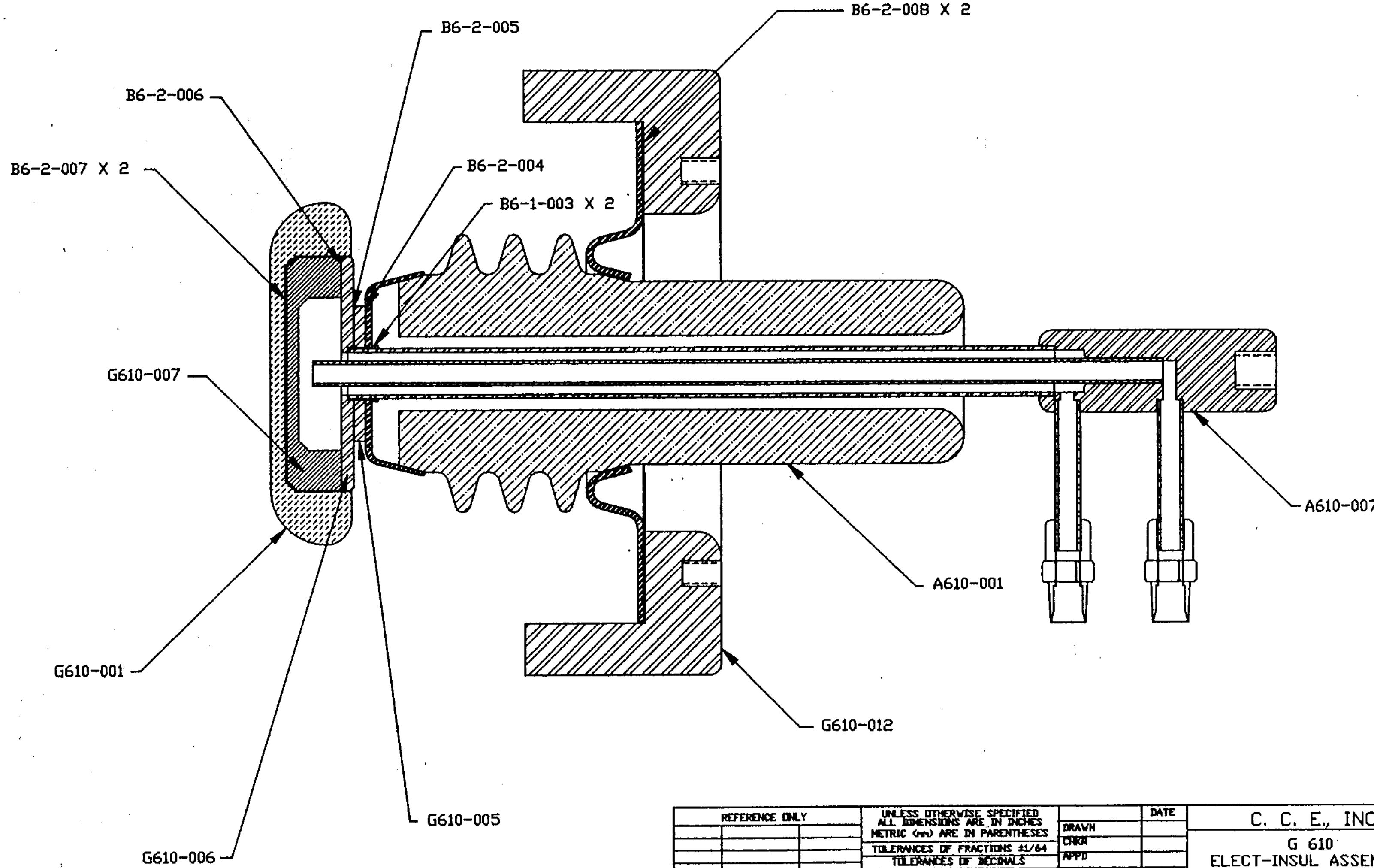
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 610
HV INSULATOR ASSEMBLY
EXPLODED VIEW

CAGE CODE	DRAWING NO.	REV
0Z887	A610-1EX	A
SCALE	WEIGHT	SHEET OF



REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | (±0.5°)

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

DRAWN | DATE

CHKR

APPD

CONTRACT/JOB NUMBER

C. C. E., INC.

G 610

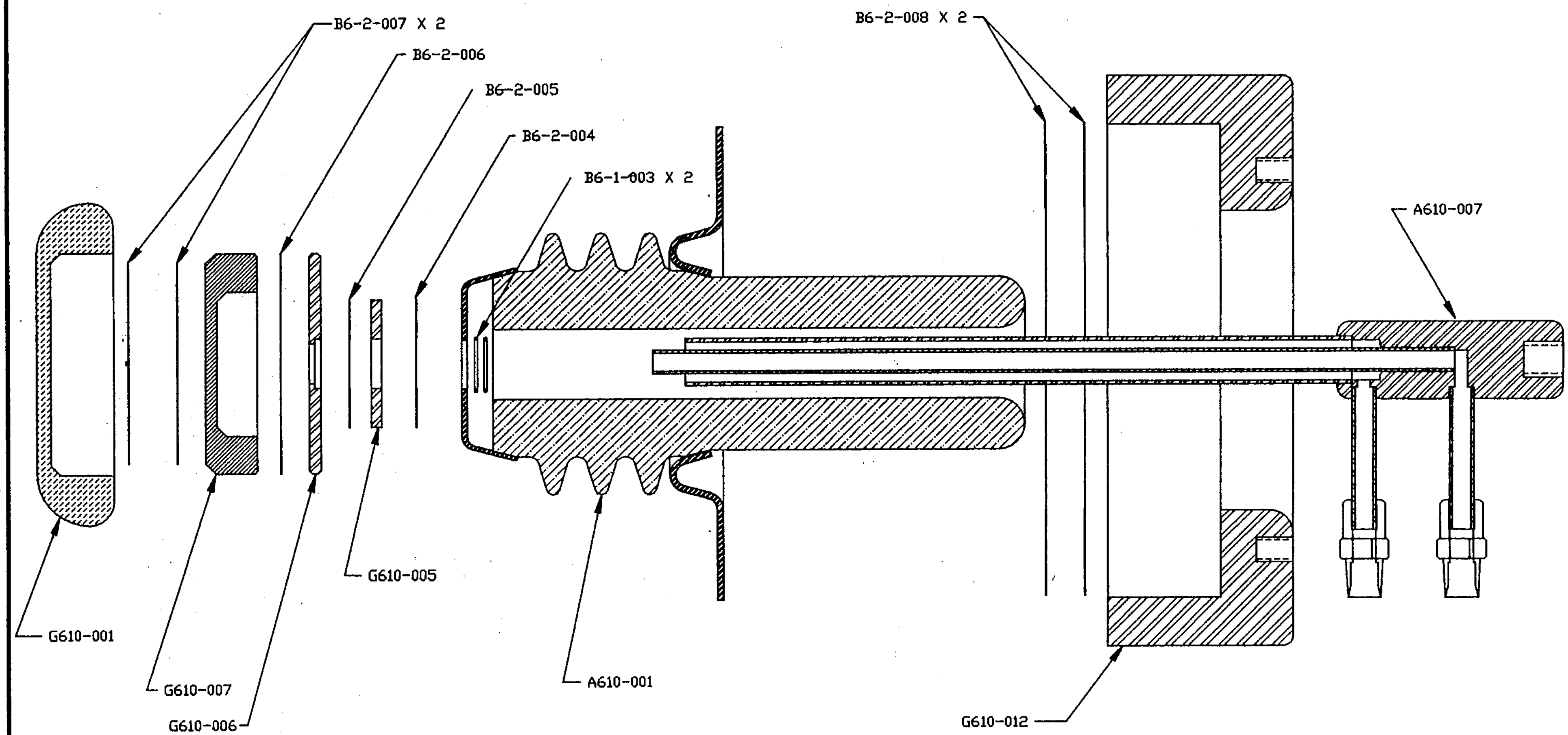
ELECT-INSUL ASSEMBLY

BRAZED

CAGE CODE 0Z887 | DRAWING NO. A610-003 | REV A

SCALE | WEIGHT | SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

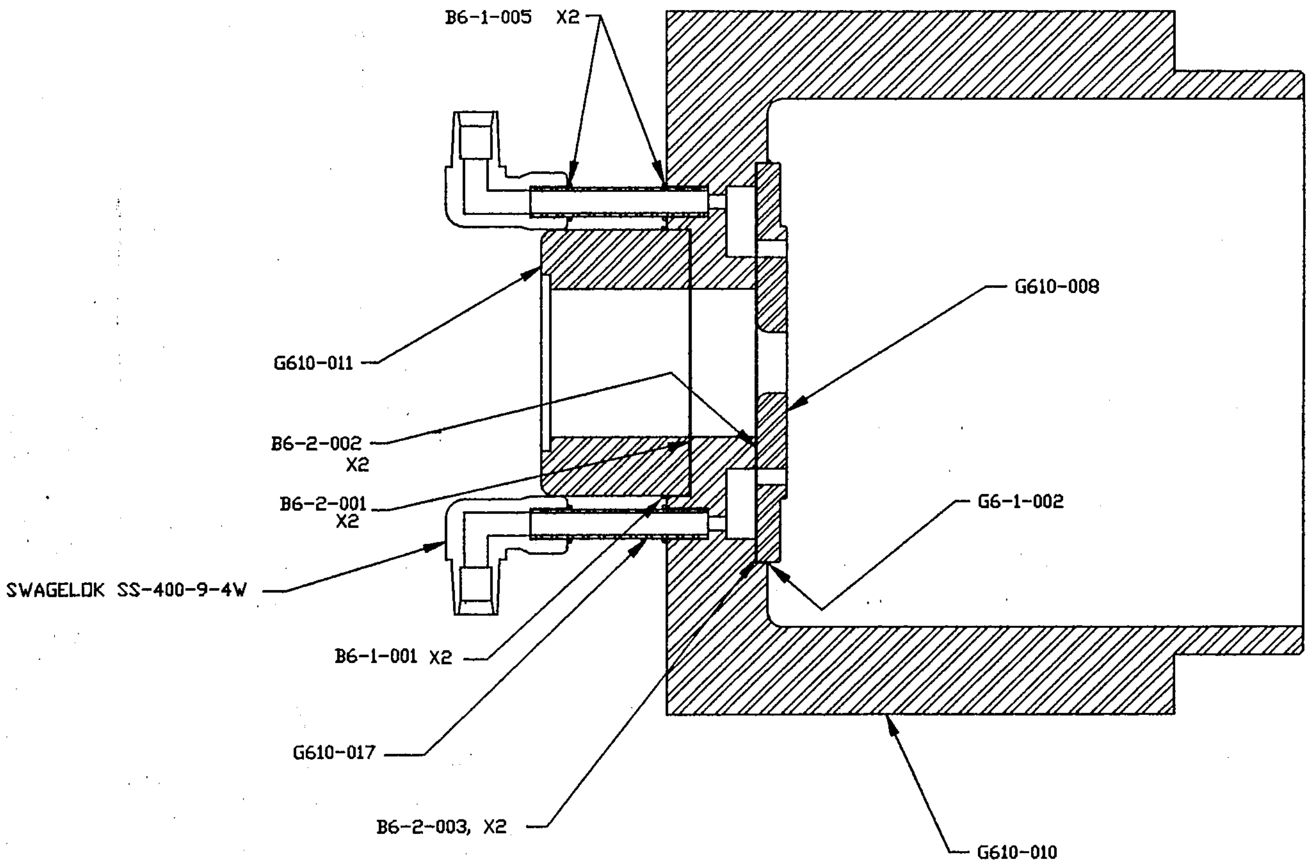
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	
CONTRACT/JOB NUMBER	

C. C. E., INC.

G 610
ELECT-INSUL ASSEMBLY

CAGE CODE	DRAWING NO.	REV
0Z887	A610-3EX	A
SCALE	WEIGHT	SHEET OF

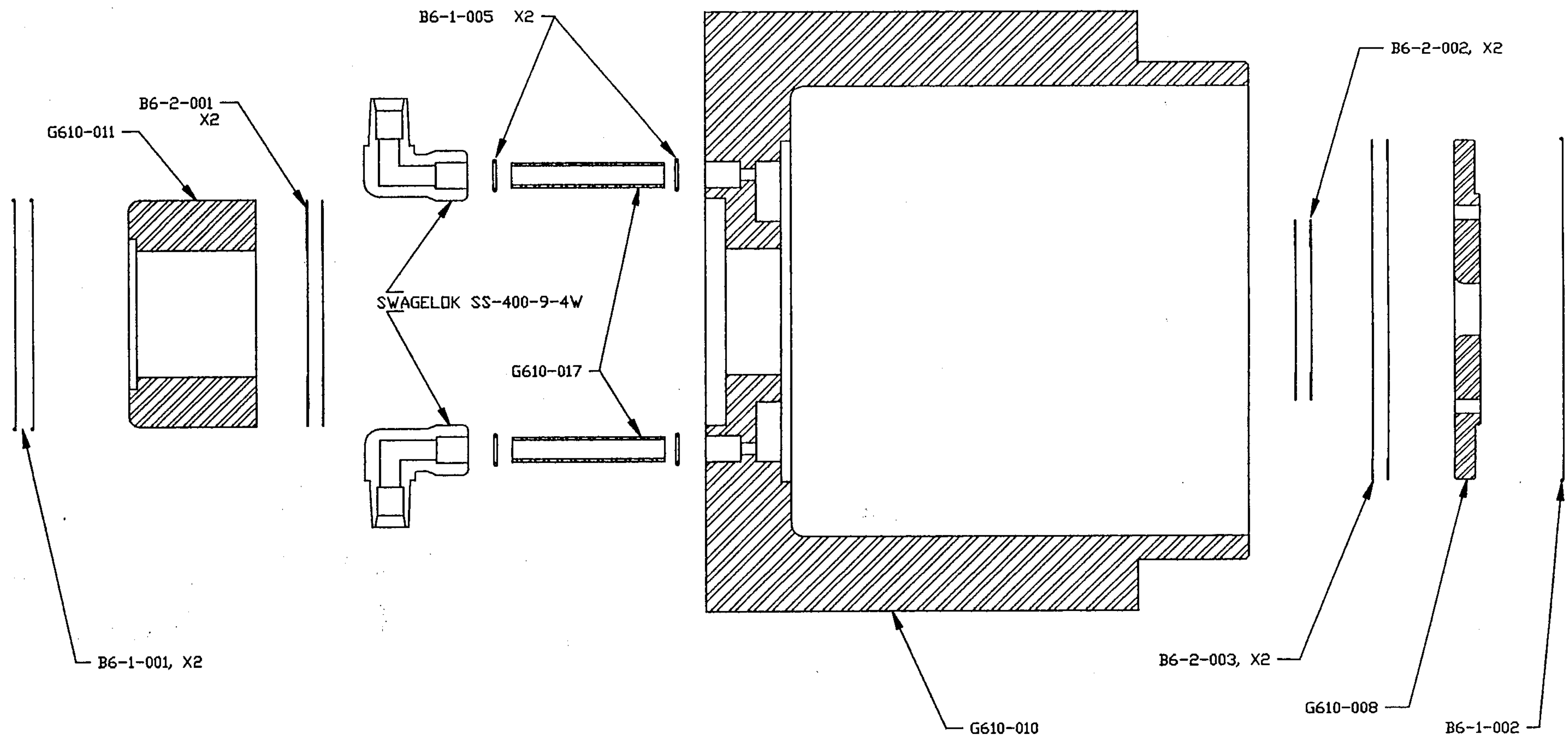


NOTE:
EXHAUST TUBULATION, G610-016, AND
SOLDER RING B6-1-005 NOT SHOWN

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES	DRAWN / CHKR / APPD / DATE
	TOLERANCES OF FRACTIONS ±1/64	
	TOLERANCES OF DECIMALS: .X ±0.01 .XX ±0.005 ∠±0.5°	
	1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.	CONTRACT/JOB NUMBER
PART NO. / NEXT ASSY. / USED ON / APPLICATION		

C. C. E., INC.		
G 610 ENCLOSURE ASSEM BRAZED		
CAGE CODE 0Z887	DRAWING NO. A610-005	REV A
SCALE	WEIGHT	SHEET OF



NOTE:
EXHAUST TUBULATION, G610-016, AND
BRAZE RING B6-1-005 NOT SHOWN

REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

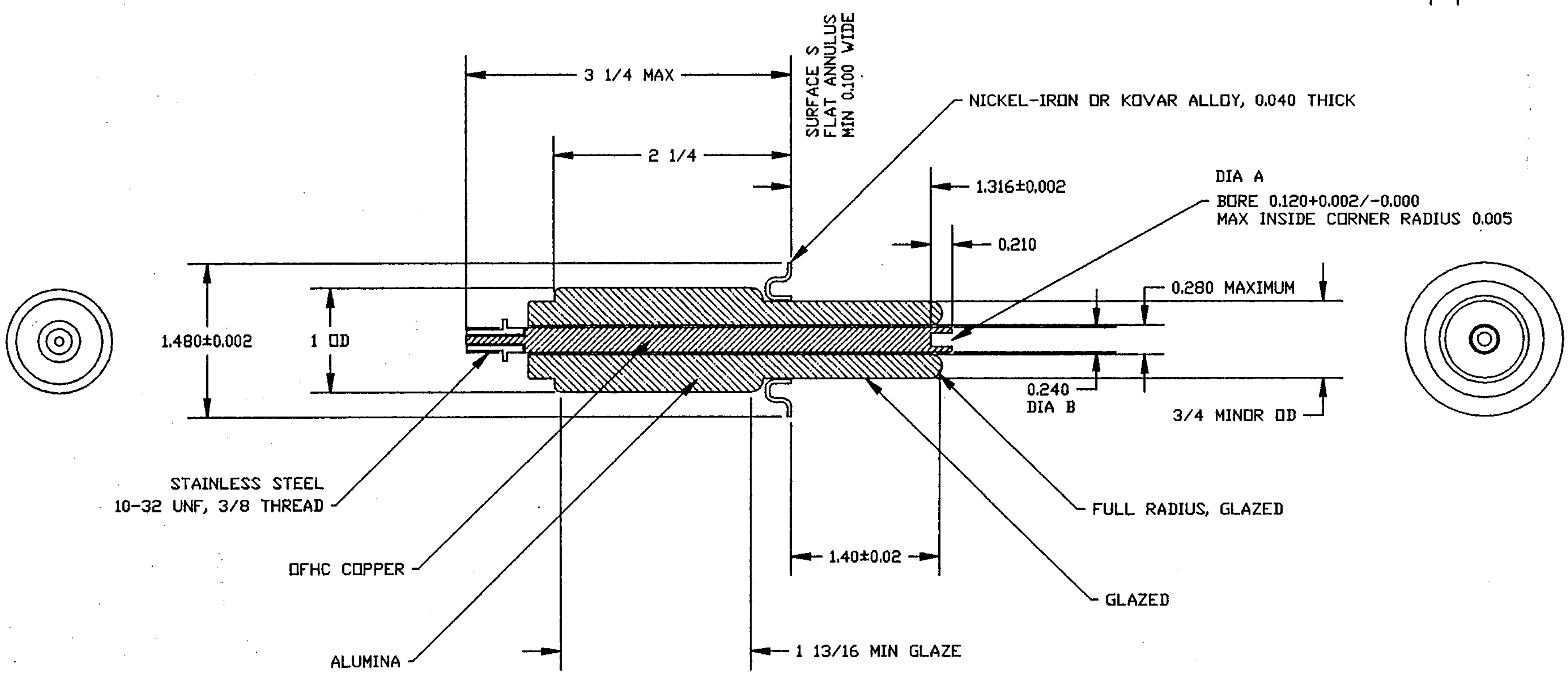
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
ENCLOSURE ASSEM
EXPL., BEFORE BRAZE

CAGE CODE	DRAWING NO.	REV
0Z887	A610-5EX	A

SCALE	WEIGHT	SHEET OF



NOTES:
ALL BRAZES MUST BE VACUUM TIGHT AFTER SUBSEQUENT STEP BRAZES AT 925 DEG C AND LESS
DAI'S A, B, AND C CONCENTRIC 0.002 TIR
SURFACE S PERPENDICULAR DIA A 0.002 TIR
FLANGE, SURFACE S, FLAT BETWEEN DIA C OD (1.480) AND 1.300 DIA

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

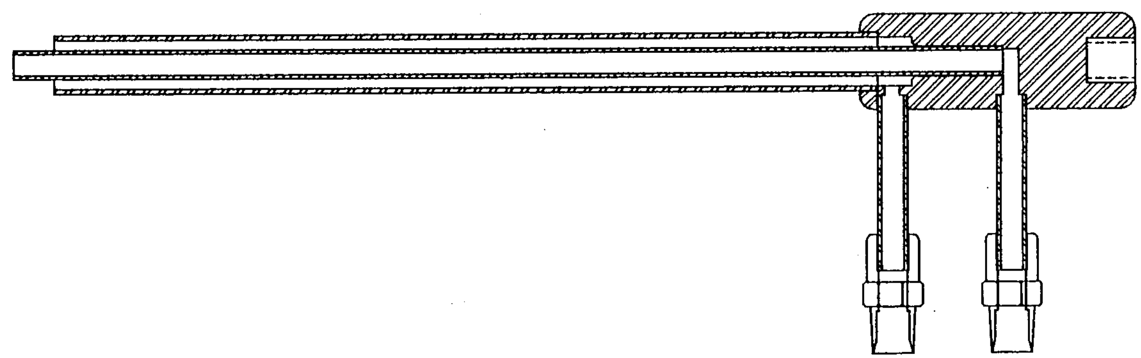
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
TRIGGER INSULATOR ASSEM
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A610-006	B
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

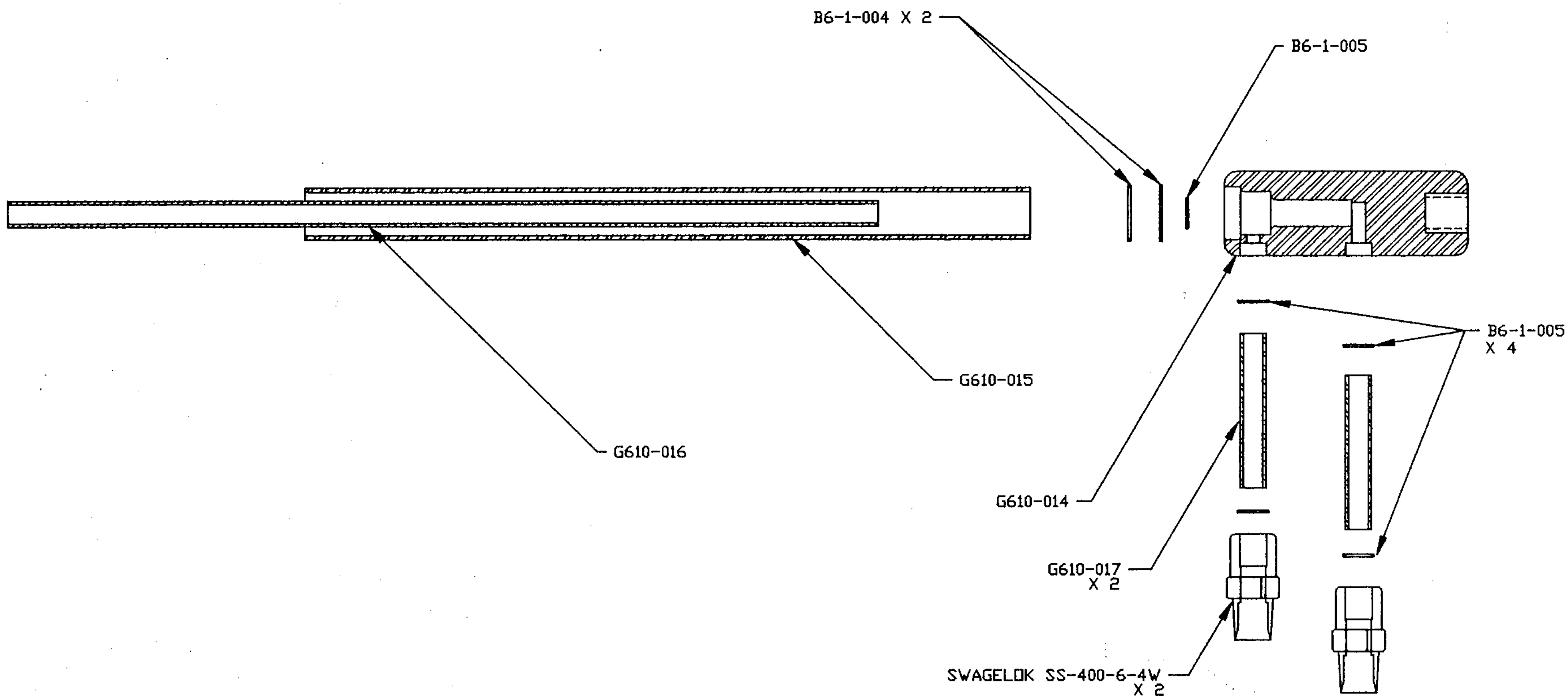
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 610
WATER TUBING ASSEM

CAGE CODE	DRAWING NO.	REV
0Z887	A610-007	B
SCALE	WEIGHT	SHEET OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO.	NEXT ASSY.	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

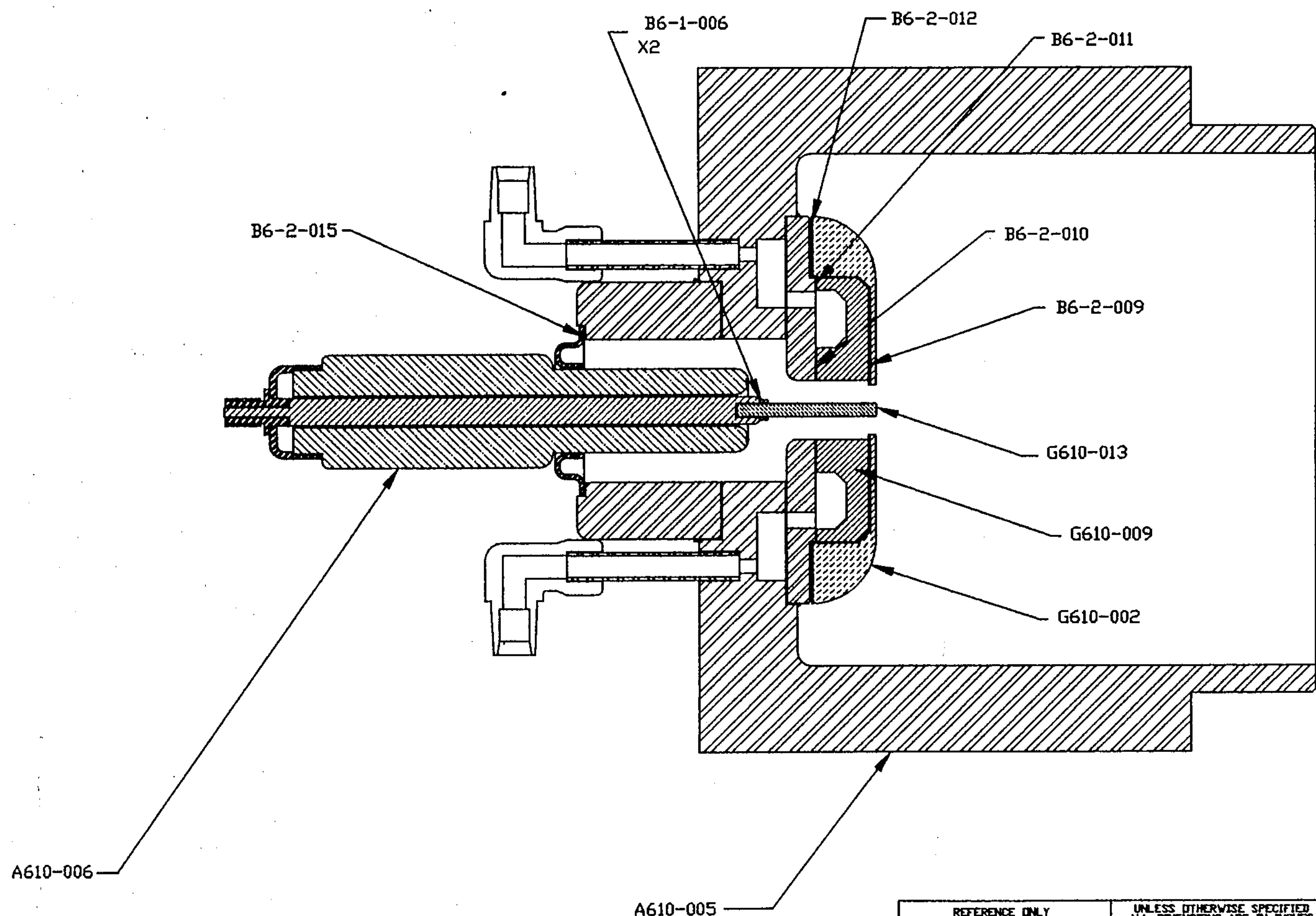
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
WATER TUBING ASSEM

CAGE CODE	DRAWING NO.	REV
0Z887	A610-7EX	B
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. $\sqrt{}$

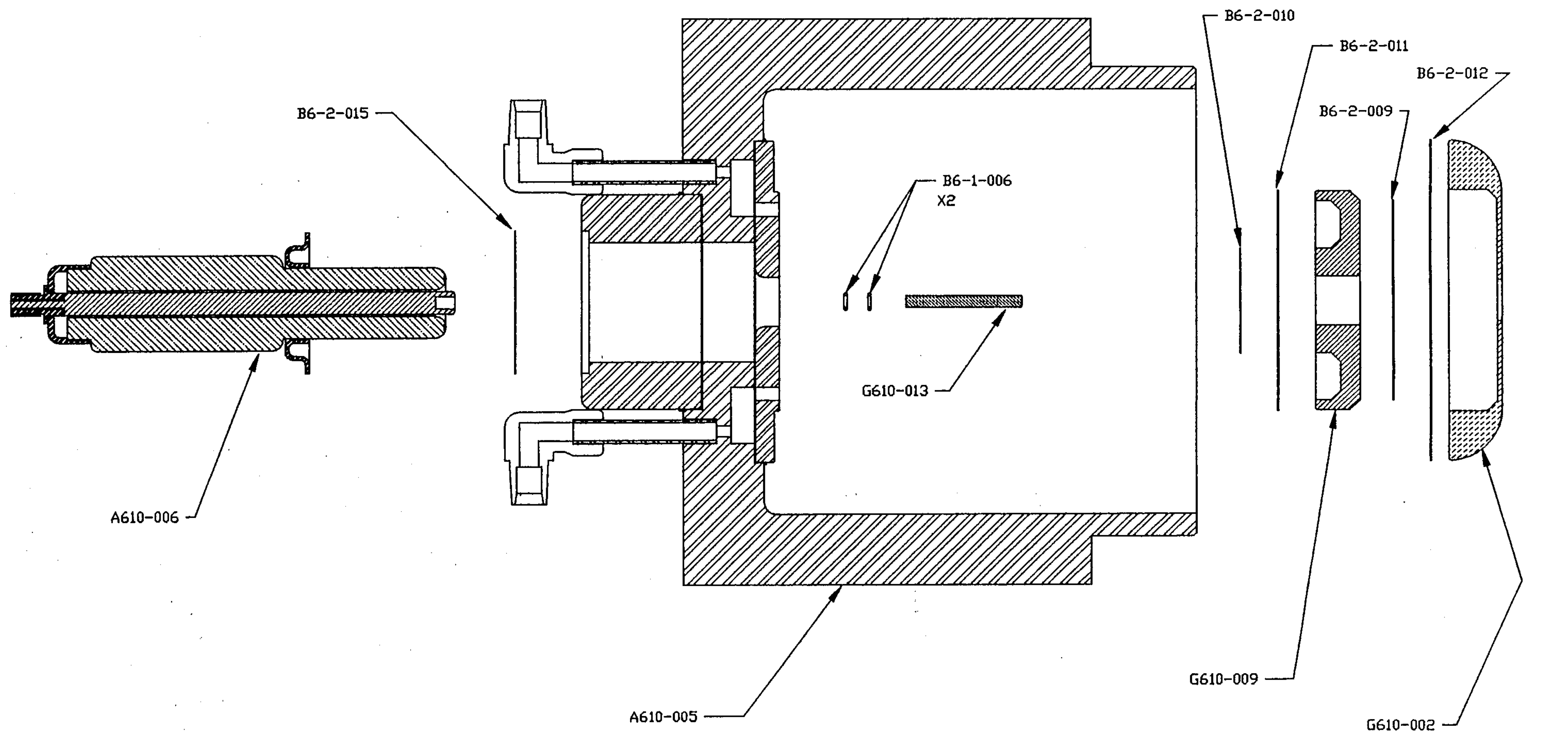
		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 610
ADJACENT ELECT ASSEM
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A610-008	A

SCALE	WEIGHT	SHEET OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∢±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. √

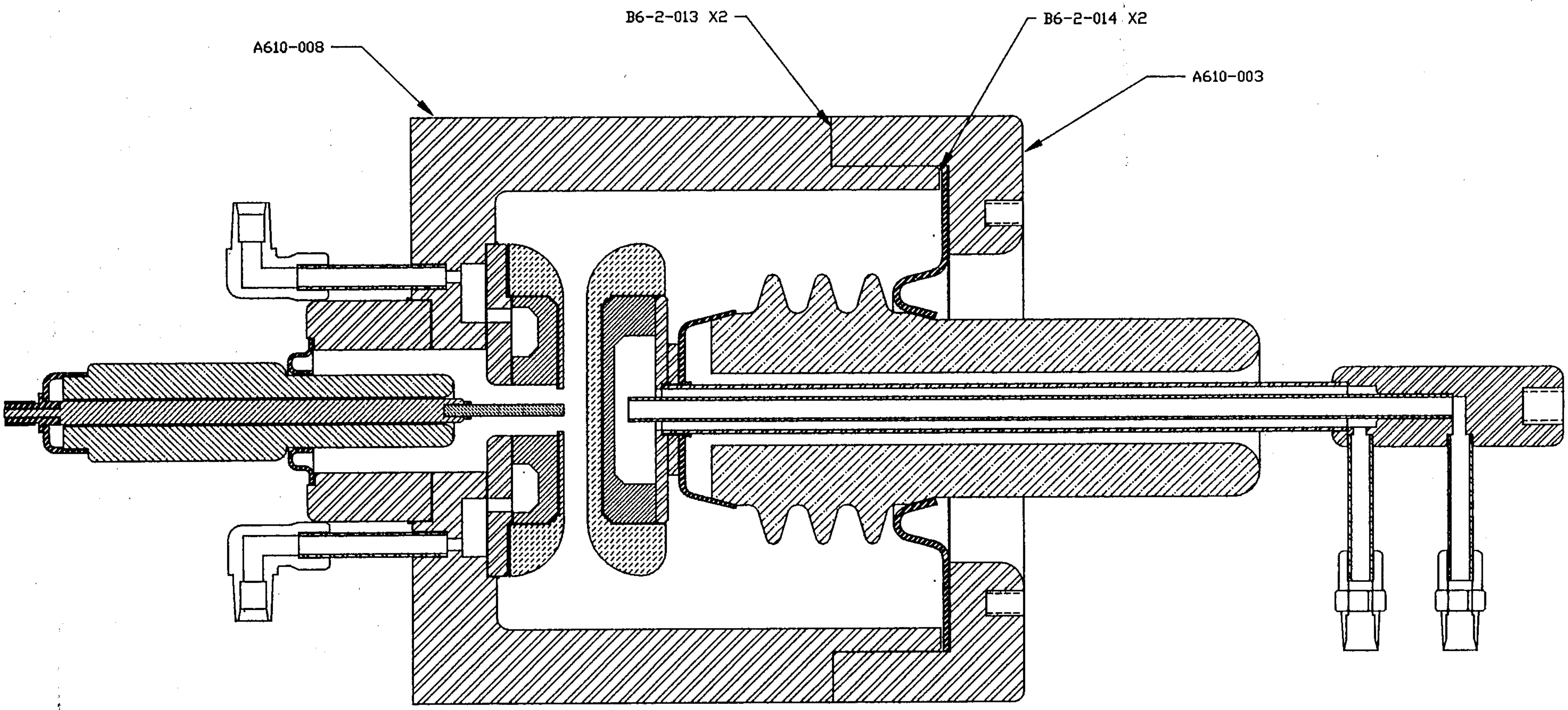
DRAWN | CHKR | APPD | DATE

CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
ADJACENT ELECT ASSEM
EXPLODED

CAGE CODE 0Z887 | DRAWING NO. A610-8EX | REV A
SCALE | WEIGHT | SHEET OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. ✓

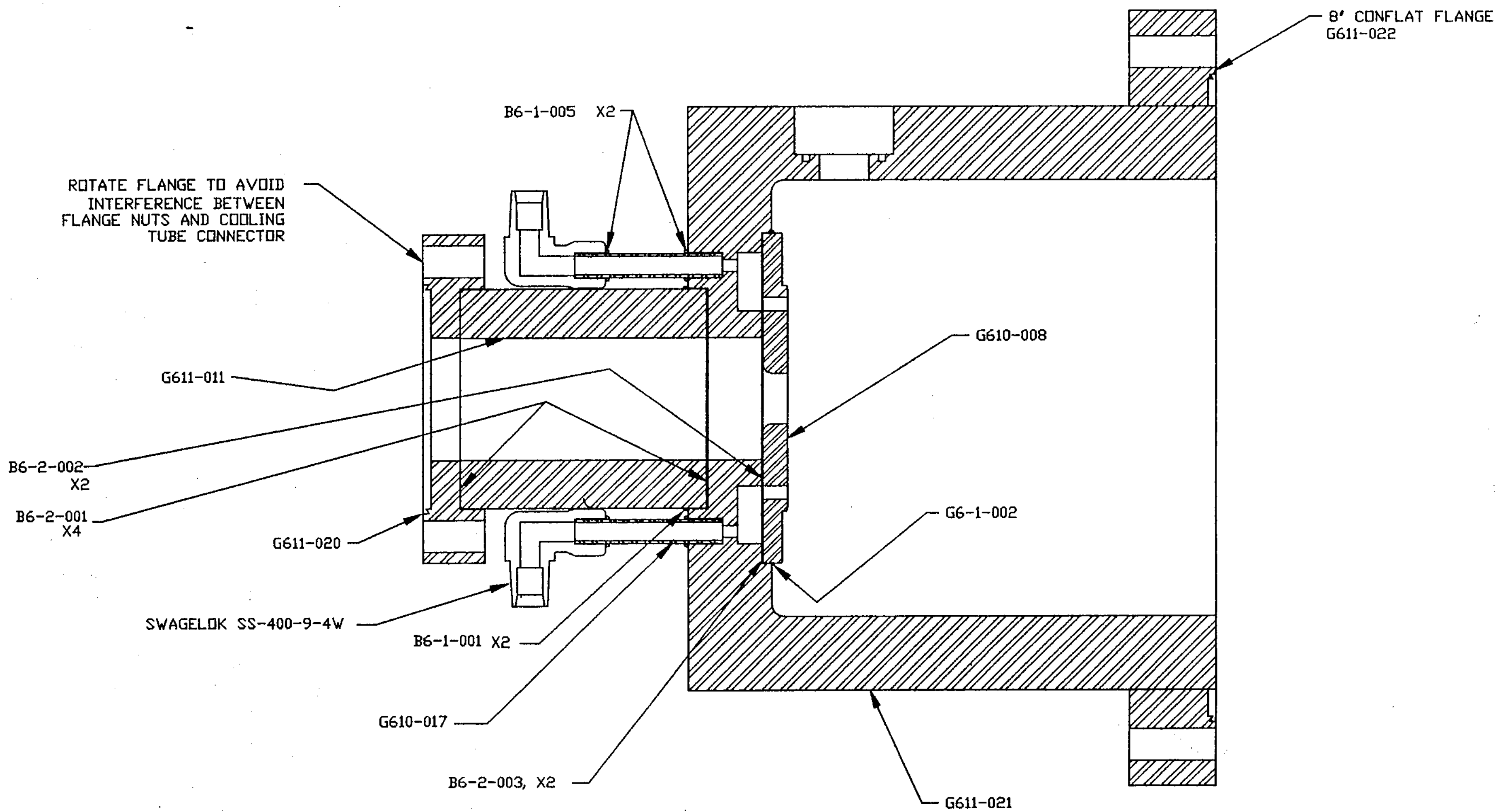
		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 610
FINAL GAP ASSEMBLY
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A610-010	A
SCALE	WEIGHT	SHEET OF

DEMOUNTABLE GAP PARTS AND ASSEMBLIES



NOTE:
EXHAUST TUBULATION, G610-016, AND
SOLDER RING B6-1-005 NOT SHOWN

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

DRAWN | CHKR | APPD | DATE

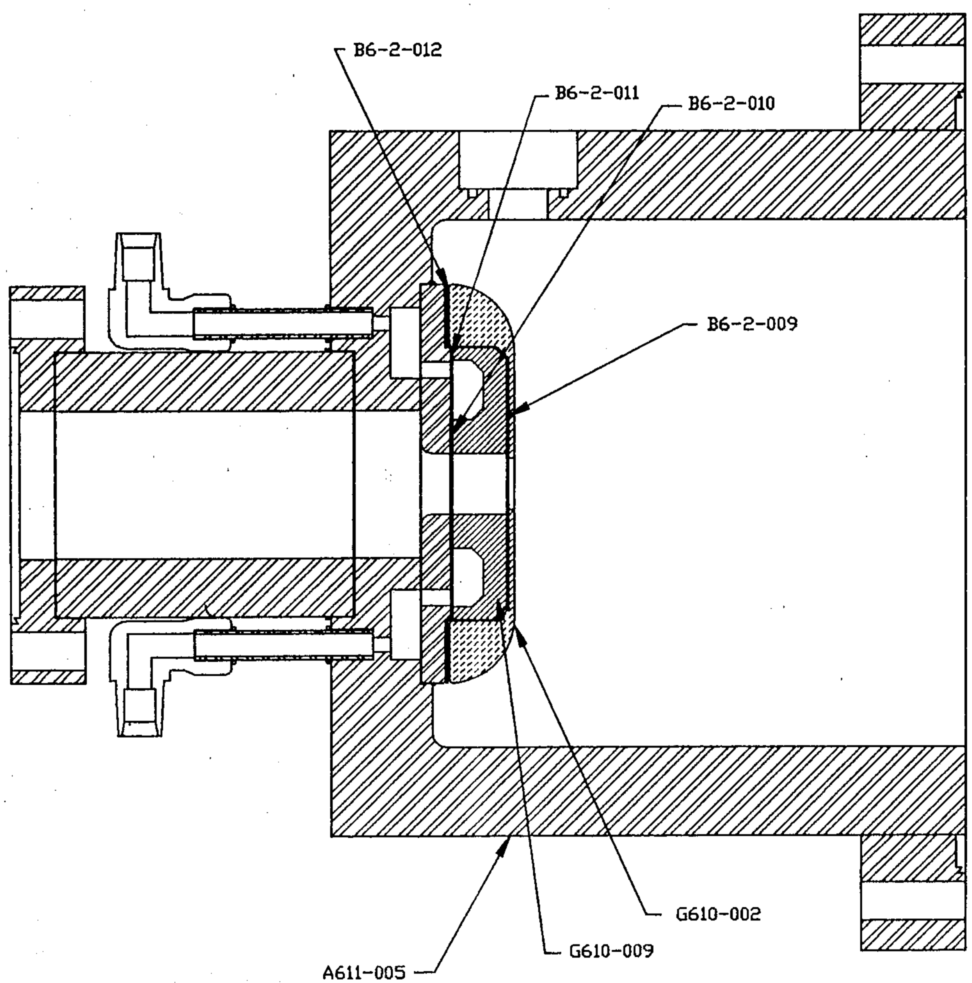
CONTRACT/JOB NUMBER

C. C. E., INC.

G 610
ENCLOSURE ASSEM
BRAZED

CAGE CODE 0Z887 | DRAWING NO. A611-005 | REV A
SCALE | WEIGHT | SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



NOTE:
EXHAUST TUBULATION, G610-016, AND
SOLDER RING B6-1-005 NOT SHOWN

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. √

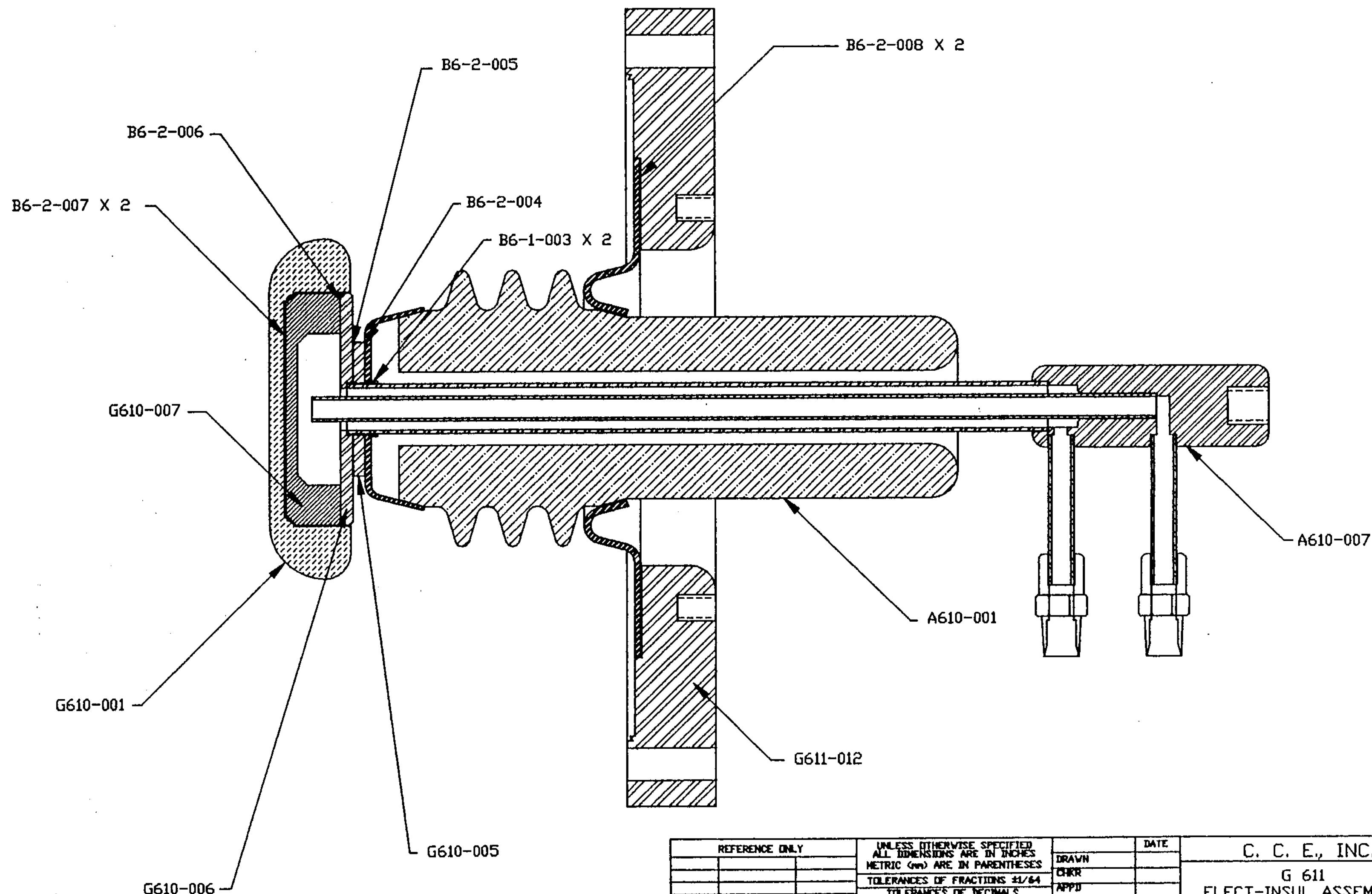
	DATE
DRAWN	
CHKR	
APPD	
CONTRACT/JOB NUMBER	

C. C. E., INC.

G 610
ADJACENT ELECT ASSEM
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A611-008	A
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

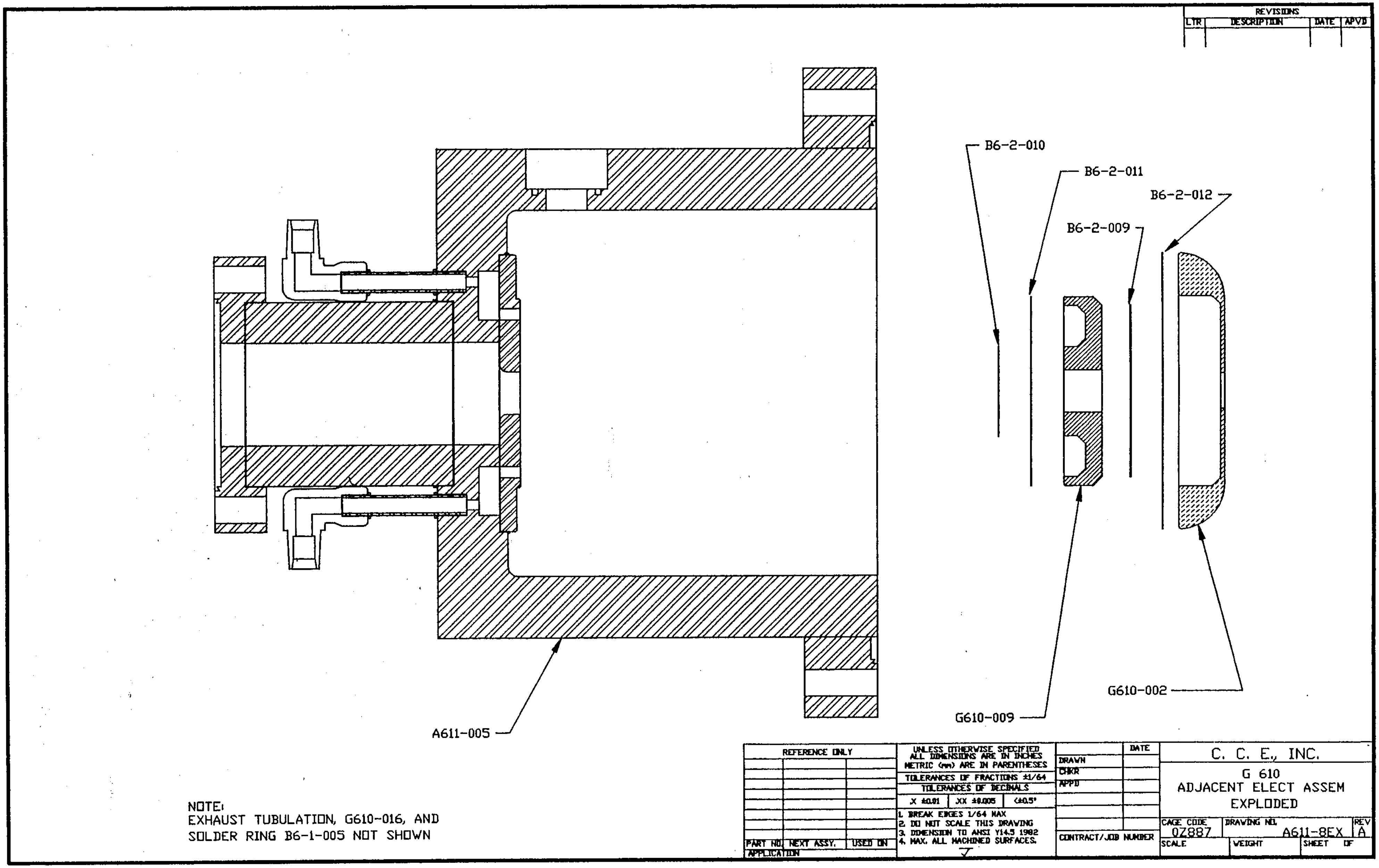
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

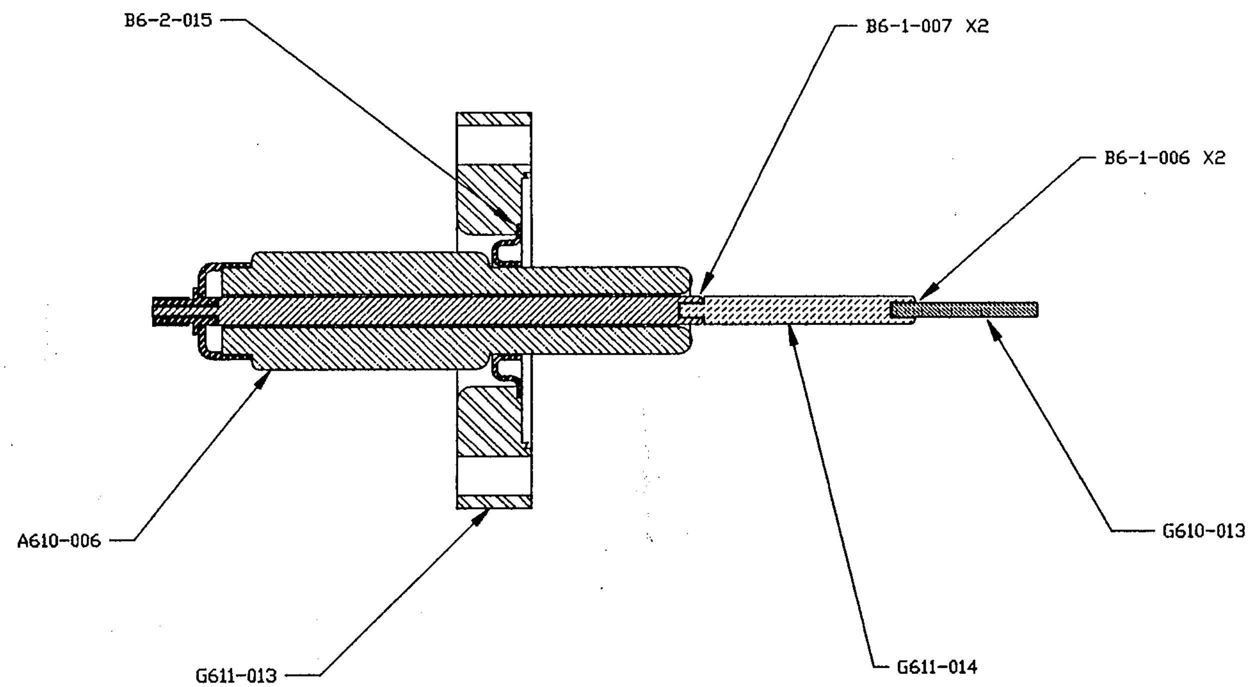
		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 611
ELECT-INSUL ASSEMBLY
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A611-003	A
SCALE	WEIGHT	SHEET OF


REVISIONS
LTR
DESCRIPTION
DATE
APVD
B6-2-010
B6-2-011
B6-2-012
B6-2-009
G610-002
G610-009
A611-005
NOTE:
EXHAUST TUBULATION, G610-016, AND
SOLDER RING B6-1-005 NOT SHOWN
REFERENCE ONLY
PART NO.
NEXT ASSY.
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01
.XX ±0.005
∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.
DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER
C. C. E., INC.
G 610
ADJACENT ELECT ASSEM
EXPLODED
CAGE CODE
0Z887
DRAWING NO.
A611-8EX
REV
A
SCALE
WEIGHT
SHEET
OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

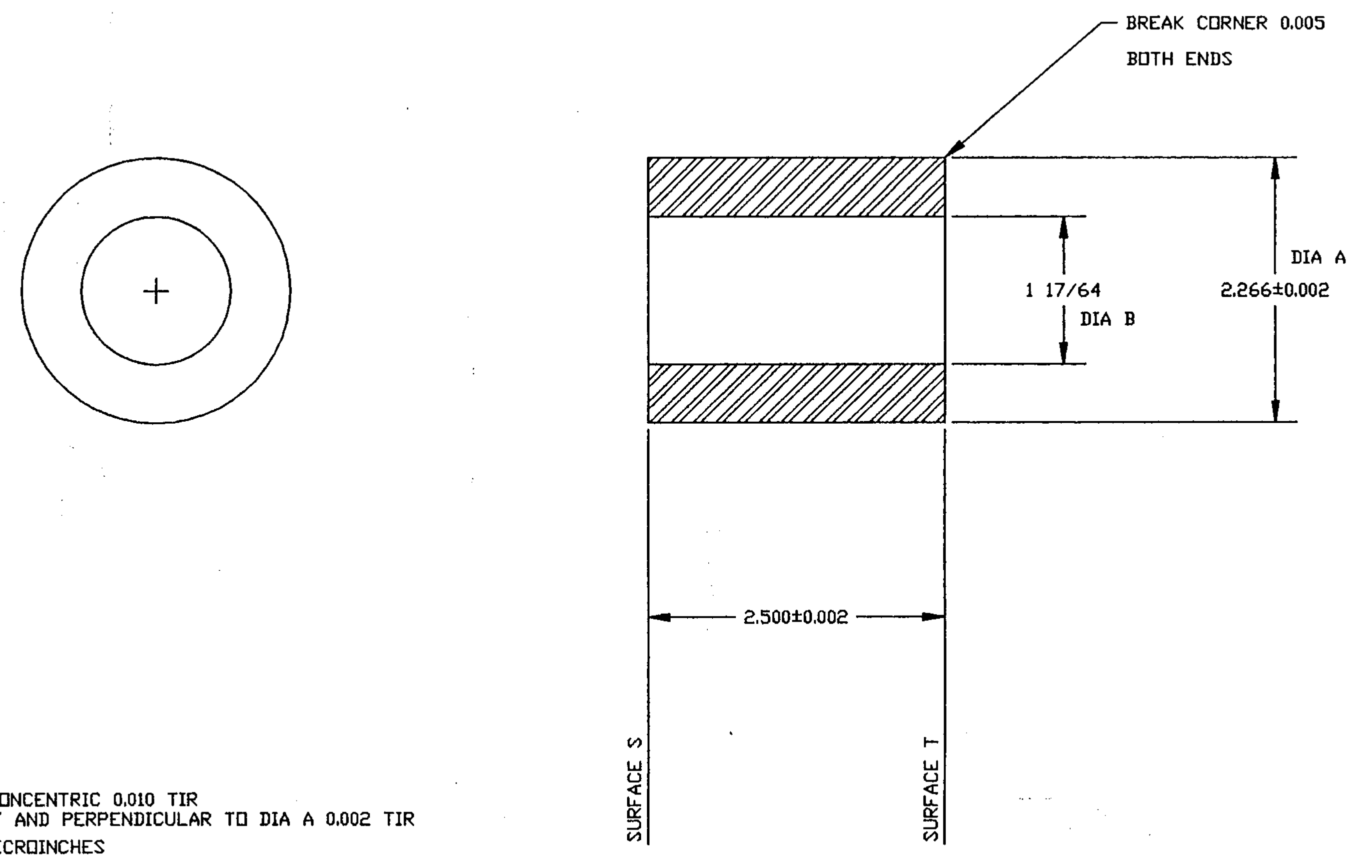
		DATE
DRAWN		
CHKR		
APPD		

CONTRACT/JOB NUMBER

C. C. E., INC.

G 611
TRIGGER INSULATOR ASSEM
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	A611-009	A
SCALE	WEIGHT	SHEET OF

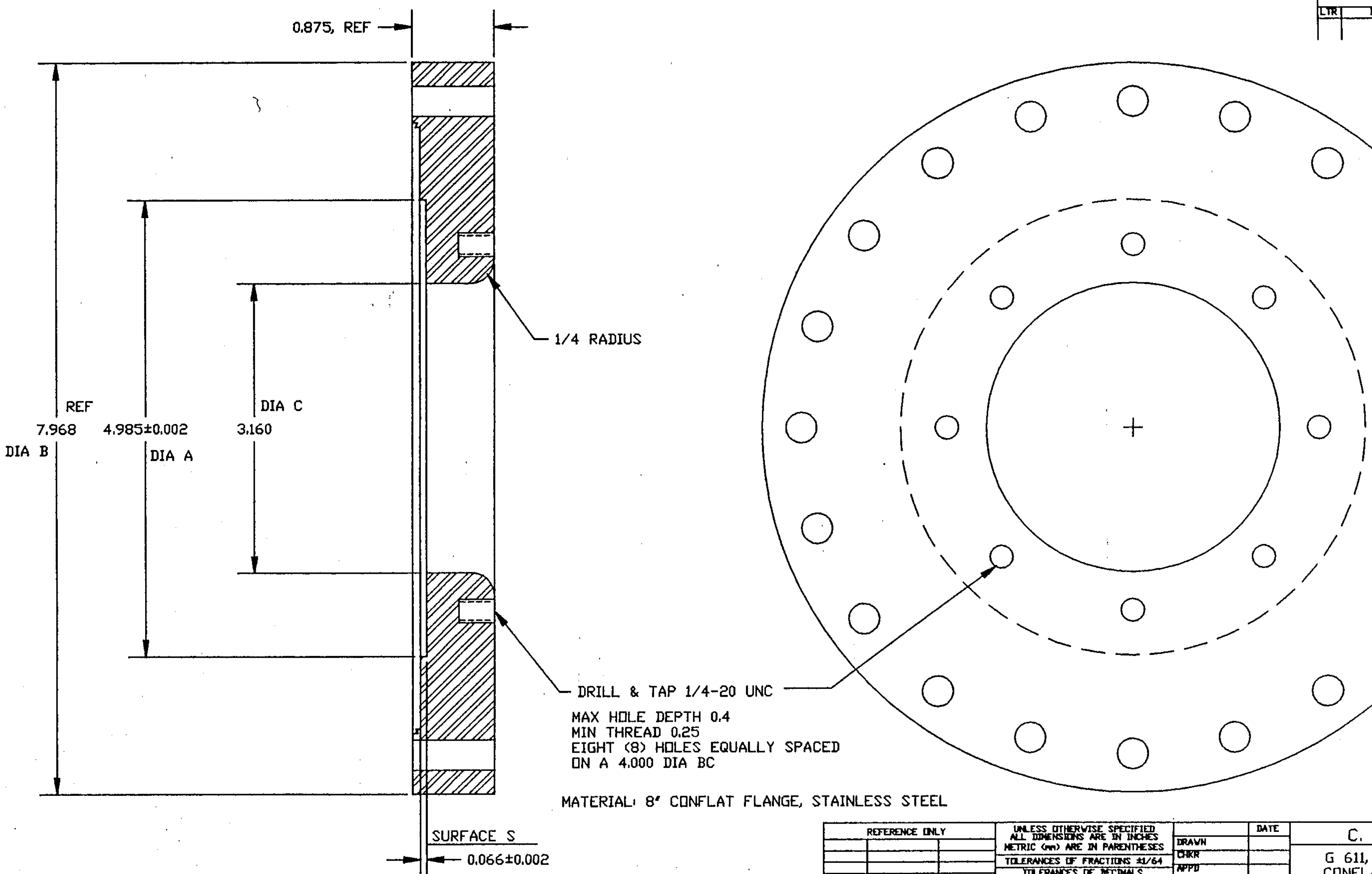


NOTES:
DIAMETERS A AND B CONCENTRIC 0.010 TIR
SURFACES S & T FLAT AND PERPENDICULAR TO DIA A 0.002 TIR
SURFACE FINISH 32 MICROINCHES

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY			UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES		DATE	C. C. E., INC.
			TOLERANCES OF FRACTIONS ±1/64	DRAWN		G 611 TRIGGER ASSEM SPACER
			TOLERANCES OF DECIMALS	CHKR		
			.X ±0.01 · .XX ±0.005 · ∠±0.5°	APPD		
			1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.			CAGE CODE 0Z887 · DRAWING NO. G611-011 · REV B
PART NO.	NEXT ASSY.	USED ON		CONTRACT/JOB NUMBER		SCALE · WEIGHT · SHEET OF
APPLICATION						



MATERIAL: 8" CONFLAT FLANGE, STAINLESS STEEL

NOTES:
DIA'S B & C CONCENTRIC DIA A 0.010 TIR
SURFACE S FLAT AND PERPENDICULAR TO DIA A 0.002 TIR
INSIDE CORNER RADIUS 0.005 MAX

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

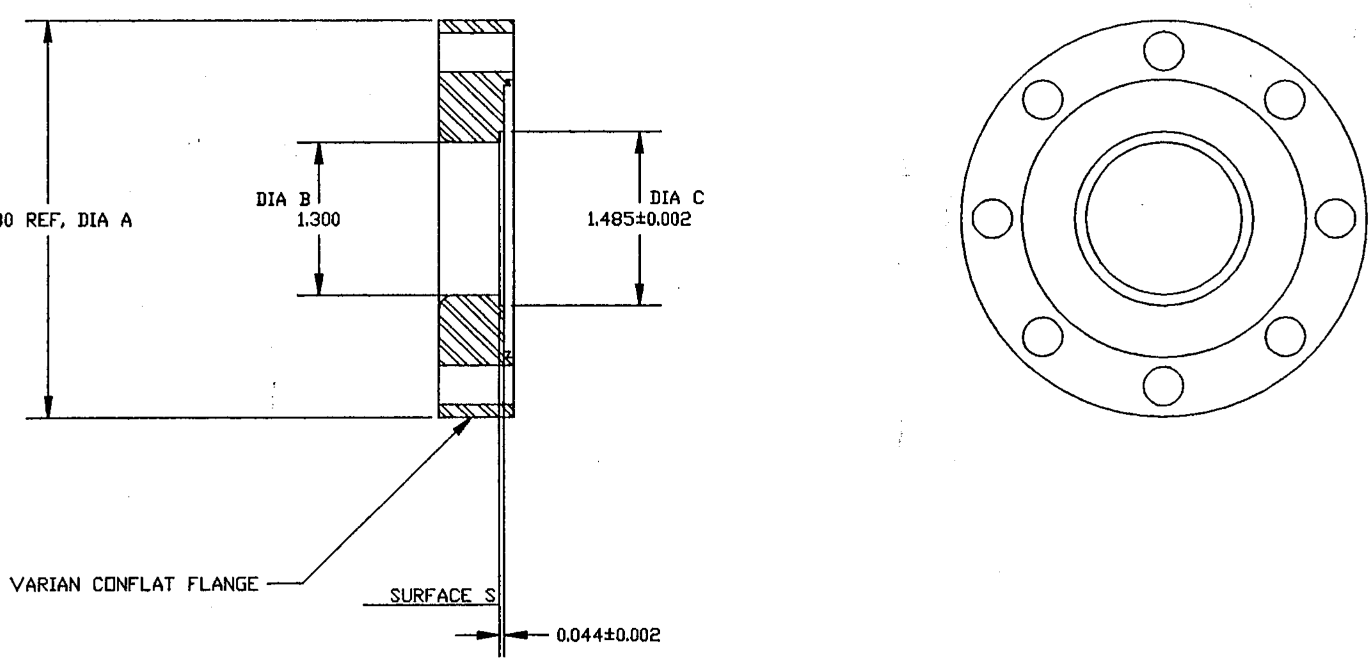
CONTRACT/JOB NUMBER

C. C. E., INC.

G 611, DEMOUNTABLE
CONFLAT END PLATE
MAIN INSL ASSEM

CAGE CODE	DRAWING NO.	REV
0Z887	G611-012	B

SCALE | WEIGHT | SHEET OF



NOTES:
DIA A, B, AND C CONCENTRIC 0.002 TIR
SURFACE S FLAT AND PERPENDICULAR DIA A 0.002 TIR

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

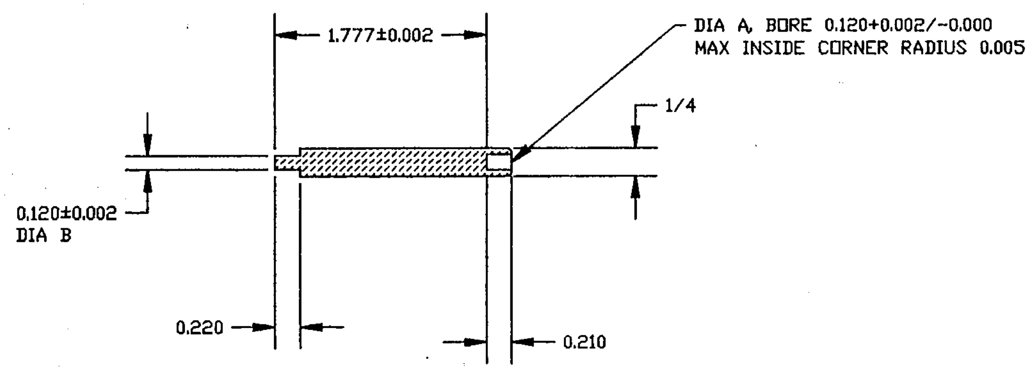
REFERENCE ONLY		
PART NO	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | <±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.
G 611
TRIGGER FLANGE

CAGE CODE	DRAWING NO.	REV
0Z887	G611-013	A
SCALE	WEIGHT	SHEET OF



NOTES:
DIAS A AND B CONCENTRIC 0.002 TIR

MATERIAL: OFHC COPPER

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

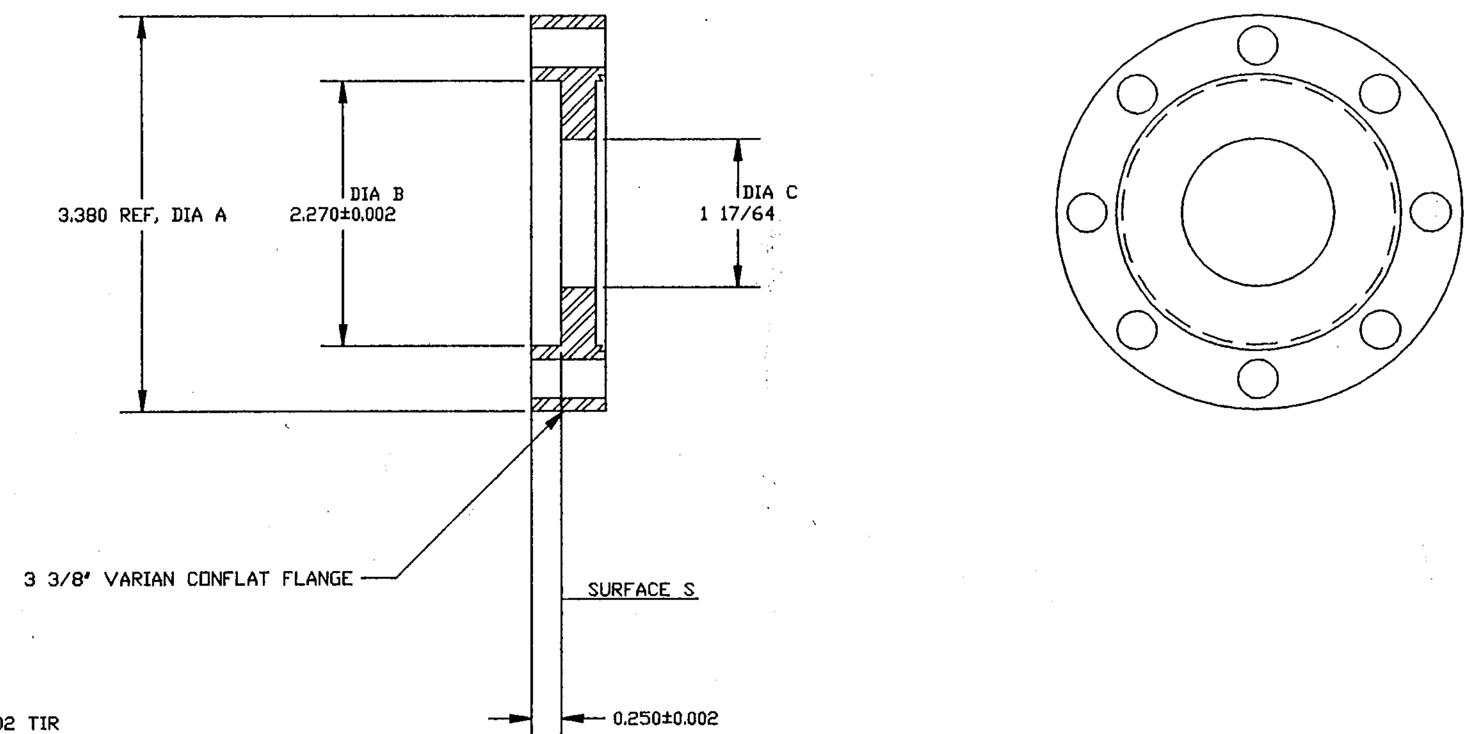
		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 611
TRIGGER EXTENDER
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	G611-014	A
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



NOTES:
DIA A, AND B CONCENTRIC 0.002 TIR
SURFACE S FLAT AND PERPENDICULAR DIA A 0.002 TIR

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

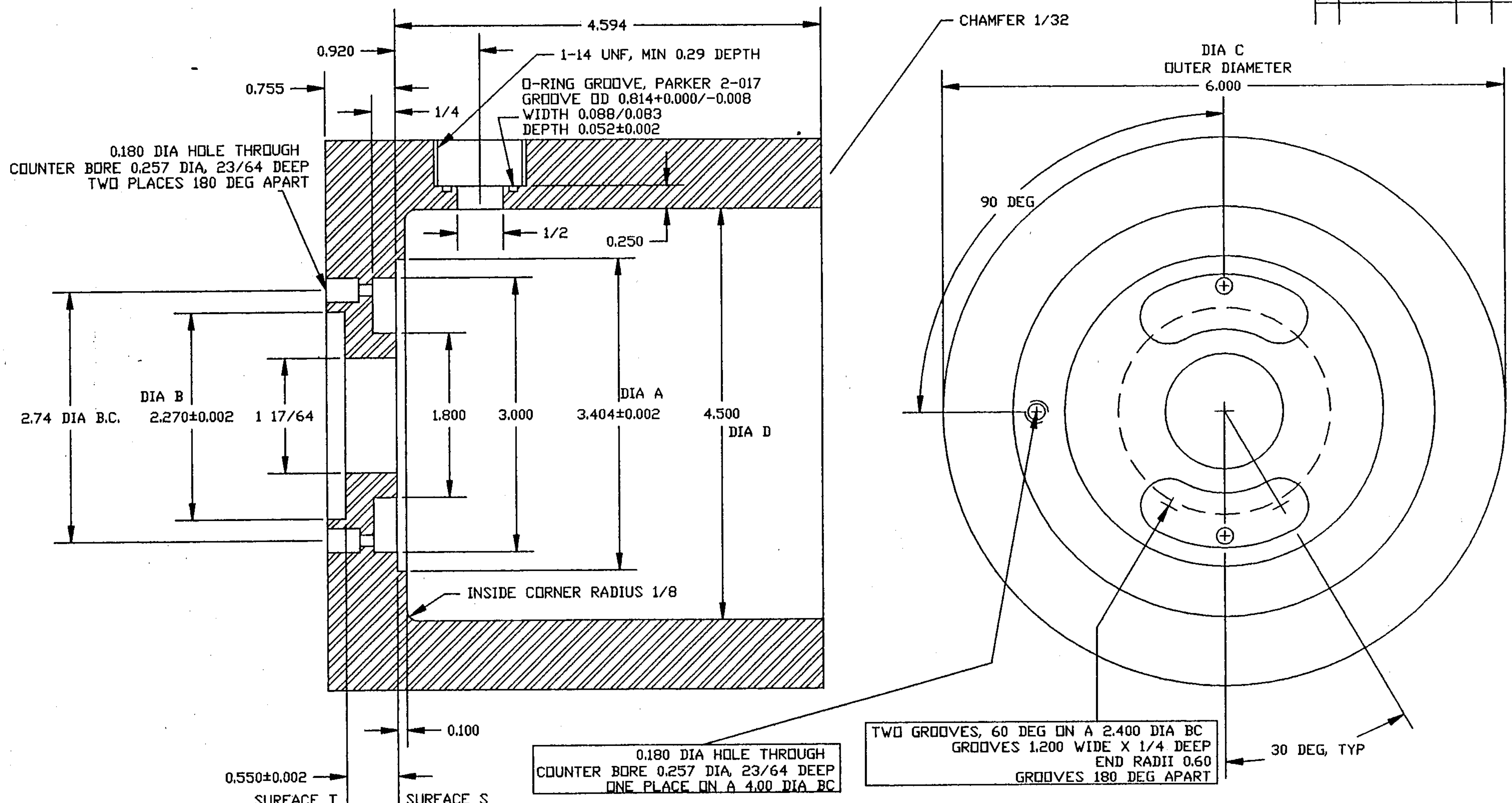
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E., INC.

G 611
BODY FLANGE, TRIGGER

CAGE CODE	DRAWING NO.	REV
0Z887	G611-020	A
SCALE	WEIGHT	SHEET OF



NOTES
DIAMETERS A & B CONCENTRIC 0.002 MAX TIR
SURFACES S & T PERPENDICULAR TO DIA A TO 0.002 TIR
DIAMETERS A, C, & D CONCENTRIC 0.005 MAX TIR
SURFACE FINISH 32 MICROINCHES MAX
BREAK ALL EDGES 0.005

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

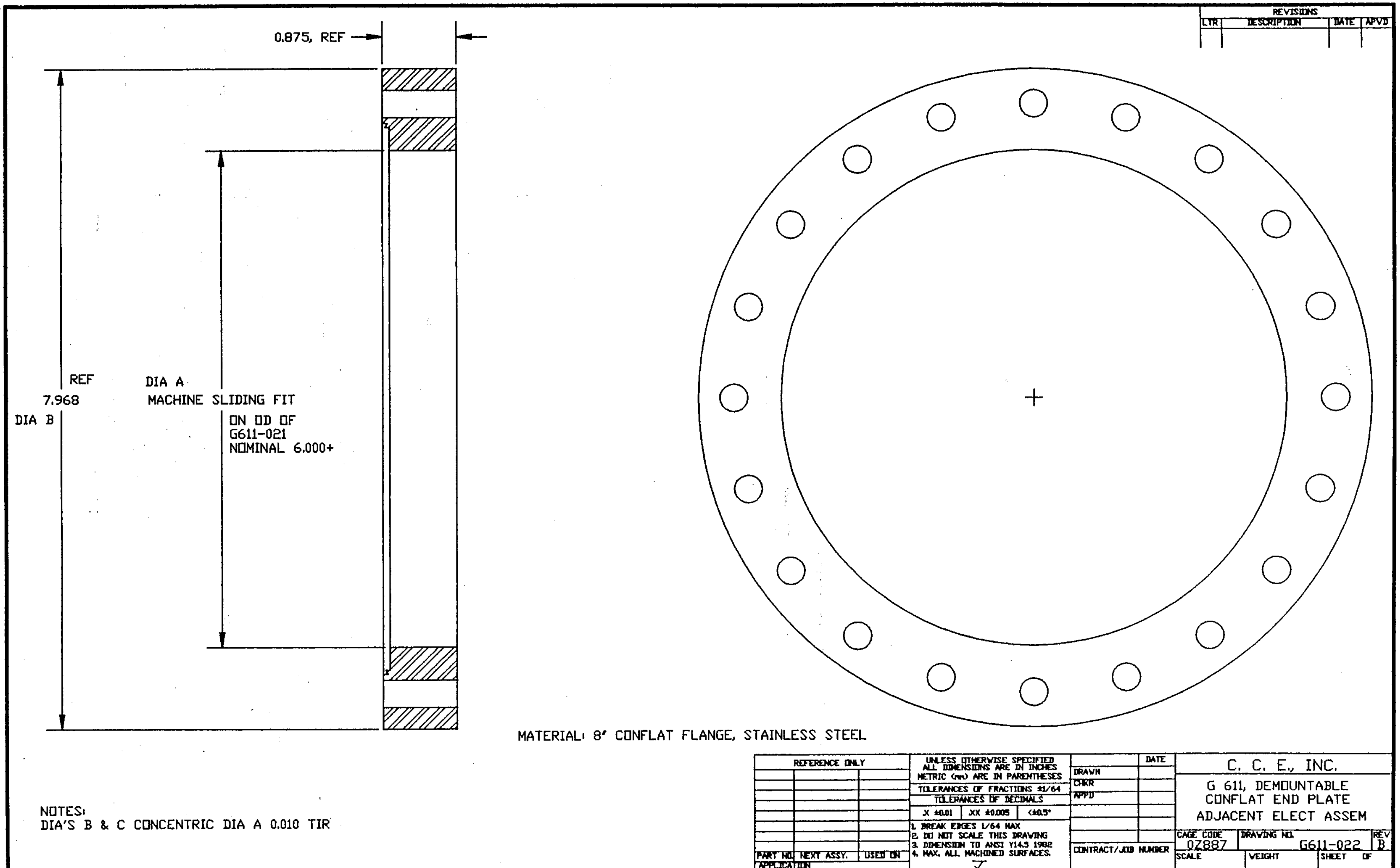
		DATE
DRAWN		
CHKR		
APPD		

CONTRACT/JOB NUMBER

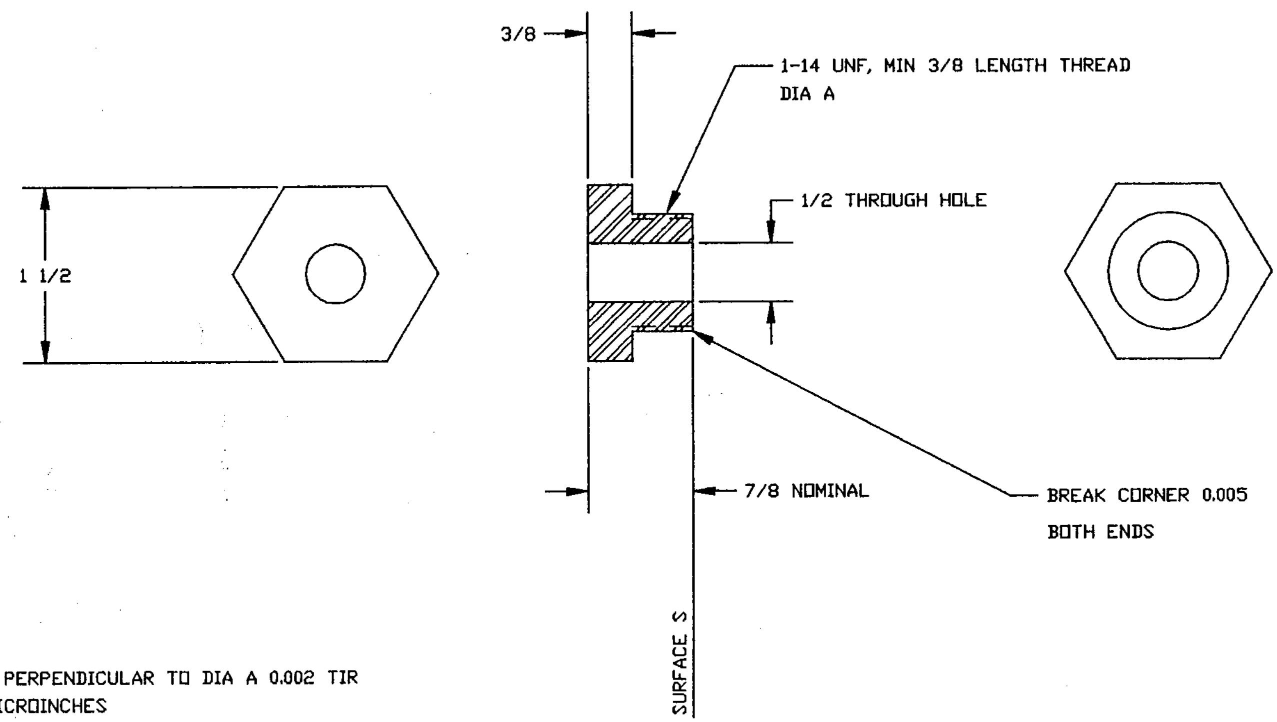
C. C. E., INC.

G 611
ADJ OUTER SHELL
STEEL ENCLOSURE

CAGE CODE	DRAWING NO.	REV
0Z887	G611-021	B
SCALE	WEIGHT	SHEET OF



REVISIONS
LTR
DESCRIPTION
DATE
APVD
0.875, REF
REF
7.968
DIA B
DIA A
MACHINE SLIDING FIT
ON OD OF
G611-021
NOMINAL 6.000+
MATERIAL: 8" CONFLAT FLANGE, STAINLESS STEEL
NOTES:
DIA'S B & C CONCENTRIC DIA A 0.010 TIR
REFERENCE ONLY
PART NO.
NEXT ASSY.
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01
.XX ±0.005
(±0.5°)
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.
DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER
C. C. E., INC.
G 611, DEMOUNTABLE
CONFLAT END PLATE
ADJACENT ELECT ASSEM
CAGE CODE
0Z887
DRAWING NO.
G611-022
REV
B
SCALE
WEIGHT
SHEET
OF



NOTES:
SURFACE S FLAT AND PERPENDICULAR TO DIA A 0.002 TIR
SURFACE FINISH 32 MICROINCHES

MATERIAL: 304 STAINLESS STEEL

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	

CONTRACT/JOB NUMBER

C. C. E., INC.

G 611
WINDOW RETAINER

CAGE CODE	DRAWING NO.	REV
0Z887	G611-023	B
SCALE	WEIGHT	SHEET OF

FLOW CHARTS

C. C. E.
CUSTOMER: NSWC
TITLE : T610 SPARK GAP
BILL NO: FLOW CHART A610-005

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-5EX		ENCLOSURE ASSEMBLY					
SS1	G610-010	1	OUTER SHELL, STEEL ENCLOSURE	P013		NICKEL		
SS2	G610-017	2	WATER TUBE, ADJACENT	P013		NICKEL		
SR1	B6-1-005	5	SOLDER/BRAZE RING 1/4" I.D.	P006	P008			
FT1	A610-5EX	2	TUBE SOCKET WELD ELBOW		P008			
SS3	G610-016	1	EXHAUST TUBULATION	P013		NICKEL	HYDROGEN	
SR2			S/A SR1	P006	P008		FURNACE	A610-005
SW1	B6-2-001	2	SOLDER WASHER, 2 1/4" O.D.	P005	P008		COPPER BRAZE	
SS4	G610-011	1	TRIGGER ASSEMBLY SPACER	P013		NICKEL	1083 deg. C	
SR3	B6-1-001	2	SOLDER/BRAZE RING 2 17/64" I.D.	P006	P008			
SW2	B6-2-002	2	SOLDER WASHER, 1.80" O.D.	P005	P008			
SW3	B6-2-003	2	SOLDER WASHER, 3 25/64" O.D.	P005	P008			
SS5	G610-008	1	BACKING PLATE, ADJ. ELECTRODE	P013		NICKEL		
SR4	B6-1-002	1	SOLDER/BRAZE RING 3 25/64" I.D.	P006	P008			

C. C. E.		NAME/DATE:	
CUSTOMER:	NSWC	CUSTOMER PO:	
TITLE :	T610 SPARK GAP	CONTRACT NO:	N60921-94-C-A345 JOB #:
BILL NO: FLOW CHART	A610-008	31-Jan-95	#REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-8EX		ADJACENT ELECTRODE ASSEMBLY					
A1	A610-005	1	ENCLOSURE ASSEMBLY					
A2	A610-006	1	TRIGGER INSULATOR ASSEMBLY					
SW1	B6-2-015	1	SOLDER WASHER, 1 31/64" O.D.	P005	P008		HYDROGEN	
SR1	B6-1-006	2	SOLDER/BRAZE RING, 1/8" I.D.	P006	P008		FURNACE	
T1	G610-013	1	TRIGGER PIN	P012	P008		BRAZE	A610-008
SW2	B6-2-010	1	SOLDER WASHER, 1 7/64" O.D.	P005	P008		PALCUSIL 15	
SW3	B6-2-011	1	SOLDER WASHER, 2 21/64" I.D.	P005	P008		900/850 deg. C	
C1	G610-009	1	ADJ. ELECTRODE COOLING CHANNEL	P011				
SW4	B6-2-009	1	SOLDER WASHER, 2 1/8" O.D.	P005	P008			
SW5	B6-2-012	1	SOLDER WASHER, 3 13/32" O.D.	P005	P008			
T2	G610-002	1	ADJACENT MAIN ELECTRODE	P001	P008	P009		PAGE # 2

C. C. E.
CUSTOMER: NSWC
TITLE : T610 SPARK GAP
FLOW CHART A610-007

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-7EX		WATER TUBING ASSEMBLY					
SS1	G610-014	1	WATER CONNECTOR	P013		NICKEL		
SS2	G610-017	2	WATER TUBE ASSEMBLY	P013		NICKEL	HYDROGEN	
SR1	B6-1-005	5	SOLDER/BRAZE RINGS, 1/4" O.D.	P006	P008		FURNACE BRAZE	A610-007
FT1	A610-7EX	2	TUBE SOCKET WELD UNION		P008		COPPER	
SR2			S/A SR1	P006	P008		1083/1083 deg. C	
SR3	B6-1-004	2	SOLDER/BRAZE RING, 1/2" O.D.	P006	P008			
SS3	G610-016	1	INNER WATER TUBE ASSEMBLY	P013		NICKEL		
SS4	G610-015	1	OUTER WATER TUBE ASSEMBLY	P013		NICKEL		

C. C. E.
CUSTOMER: NSWC
TITLE : T610 SPARK GAP
FLOW CHART A610-001

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-1EX		CERAMIC INSULATOR ASSEMBLY					
CE1	G610-003	1	MAIN INSULATOR				NOTE: ASSEMBLY TO BE DONE AT CERAMIC PROCESS HOUSE	A610-001
NI1	G610-041	1	OPP. ELECTRODE SEAL CUP					
NI2	G610-042	1	MAIN INSULATOR SEAL FLANGE					

C. C. E.
CUSTOMER: NSWC
TITLE : T610 SPARK GAP
FLOW CHART A610-003

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-3EX		ELECTRICAL INSULATOR ASSEMBLY					
A1	A610-001	1	CERAMIC INSULATOR ASSEMBLY					
SR1	B6-1-003	2	SOLDER/BRAZE RING, 1/2" I.D.	P006	P008			
A2	A610-007	1	WATER TUBING ASSEMBLY					
SW1	B6-2-008	2	SOLDER WASHER, 4 63/64" O.D.	P005	P008		HYDROGEN	
SS1	G610-012	1	END PLATE	P013		NICKEL	FURNACE	
SW2	B6-2-004	1	SOLDER WASHER, 1 11/32" O.D.	P005	P008		BRAZE	A610-003
SS2	G610-005	1	OPP. ELECTRODE SPACER	P013		NICKEL	PALCUSIL 15	
SW3	B6-2-005	1	SOLDER WASHER, 1/ 11/32" O.D.	P005	P008		900/850 deg. C	
SS3	G610-006	1	OPP. ELECTRODE COOLING BACKING PLA	P013		NICKEL		
SW4	B6-2-006	1	SOLDER WASHER, 2 21/64" O.D.	P005	P008			
C1	G610-007	1	OPP. ELECTRODE COOLING CHANNEL	P011	P011			
SW5	B6-2-007	2	SOLDER WASHER, 2 1/8" O.D.	P005	P008			
T1	G610-001	1	OPPOSITE MAIN ELECTRODE	P001	P008	P009		

C. C. E.
CUSTOMER: NSWC
TITLE : T610 SPARK GAP
FLOW CHART G0610

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	G0610		FINAL SPARK GAP ASSEMBLY					
A1	A610-003	1	ELECT.- INSULATOR ASSEMBLY				HYDROGEN	
SW1	B6-2-013	2	SOLDER/BRAZE WASHER, 6.00" O.D.	P005	P008		FURNACE BRAZE	
SW2	B6-2-014	2	SOLDER/BRAZE WASHER, 4 31/32" O.D.	P005	P008		CUSIL	A610-010
A2	A610-008	1	ADJ. ELECTRODE ASSEMBLY				780/780 deg. C	
SS1		1	37 deg. 1/4" TUBE FLARE NUT			NOTE:		
SS2		1	1/4" TUBE FLARE NUT SLEEVE			AFTER COOL DOWN, FIT FLARE NUT, FLARE SLEEVE, AND FLARE EXHAUST TUBULATION AS PER PROCESS P002.		

C. C. E.
CUSTOMER: NSWC
TITLE : G611 SPARK GAP
BILL NO: FLOW CHART A611-005

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A611-005		ENCLOSURE ASSEMBLY					
SS1	G611-021	1	OUTER SHELL, STEEL ENCLOSURE	P013		NICKEL		
SS2	G610-017 -	2	WATER TUBE, ADJACENT	P013		NICKEL		
SR1	B6-1-005	5	SOLDER/BRAZE RING 1/4" I.D.	P006	P008			
FT1	A611-005	2	TUBE SOCKET WELD ELBOW		P008			
SS3	G610-016	1	EXHAUST TUBULATION	P013		NICKEL	HYDROGEN	
SR2			S/A SR1	P006	P008		FURNACE	A611-005
SW1	B6-2-001	2	SOLDER WASHER, 2 1/4" O.D.	P005	P008		COPPER BRAZE	
SS4	G611-011	1	TRIGGER ASSEMBLY SPACER	P013		NICKEL	1083 deg. C	
SR3	B6-1-001	2	SOLDER/BRAZE RING 2 17/64" I.D.	P006	P008			
SW2	B6-2-002	2	SOLDER WASHER, 1.80" O.D.	P005	P008			
SW3	B6-2-003	2	SOLDER WASHER, 3 25/64" O.D.	P005	P008			
SS5	G610-008	1	BACKING PLATE, ADJ. ELECTRODE	P013		NICKEL		
SR4	B6-1-002	1	SOLDER/BRAZE RING 3 25/64" I.D.	P006	P008			PAGE # 1
SS6	G611-020	1	TRIGGER BODY FLANGE		P008			

C. C. E.		NAME/DATE:	
CUSTOMER:	NSWC	CUSTOMER PO:	
TITLE :	G611 SPARK GAP	CONTRACT NO:	N60921-94-C-A345 JOB #:
BILL NO: FLOW CHART	A611-008	31-Jan-95	#REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A611-8EX		ADJACENT ELECTRODE ASSEMBLY					
A1	A611-005	1	ENCLOSURE ASSEMBLY					
A2	A611-009	1	TRIGGER INSULATOR ASSEMBLY	NOTE: TO BE MANUFACTURED AND ASSEMBLED BY CERAMIC PROCESS HOUSE				
SW2	B6-2-010	1	SOLDER WASHER, 1 7/64" O.D.	P005	P008			
SW3	B6-2-011	1	SOLDER WASHER, 2 21/64" I.D.	P005	P008		HYDROGEN	
C1	G610-009	1	ADJ. ELECTRODE COOLING CHANNEL	P011			FURNACE	A611-008
SW4	B6-2-009	1	SOLDER WASHER, 2 1/8" O.D.	P005	P008		BRAZE	
SW5	B6-2-012	1	SOLDER WASHER, 3 13/32" O.D.	P005	P008		PALCUSIL 15	
T2	G610-002	1	ADJACENT MAIN ELECTRODE	P001	P008	P009	900/850 deg. C	

C. C. E.
CUSTOMER: NSWC
TITLE : G611 SPARK GAP
FLOW CHART A610-007

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-7EX		WATER TUBING ASSEMBLY					
SS1	G610-014	1	WATER CONNECTOR	P013		NICKEL		
SS2	G610-017	2	WATER TUBE ASSEMBLY	P013		NICKEL	HYDROGEN	
SR1	B6-1-005	5	SOLDER/BRAZE RINGS, 1/4" O.D.	P006	P008		FURNACE BRAZE	A610-007
FT1	A610-7EX	2	TUBE SOCKET WELD UNION		P008		COPPER	
SR2			S/A SR1	P006	P008		1083/1083 deg. C	
SR3	B6-1-004	2	SOLDER/BRAZE RING, 1/2" O.D.	P006	P008			
SS3	G610-016	1	INNER WATER TUBE ASSEMBLY	P013		NICKEL		
SS4	G610-015	1	OUTER WATER TUBE ASSEMBLY	P013		NICKEL		

C. C. E.
CUSTOMER: NSWC
TITLE : G611 SPARK GAP
FLOW CHART A610-001

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A610-1EX		CERAMIC INSULATOR ASSEMBLY				NOTE:	
CE1	G610-003	1	MAIN INSULATOR				ASSEMBLY TO BE	
NI1	G610-041	1	OPP. ELECTRODE SEAL CUP				DONE AT CERAMI	A610-001
NI2	G610-042	1	MAIN INSULATOR SEAL FLANGE				PROCESS HOUSE	

C. C. E.
CUSTOMER: NSWC
TITLE : G611 SPARK GAP
FLOW CHART A611-003

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	A611-003		ELECTRODE INSULATOR ASSEMBLY					
A1	A610-001	1	CERAMIC INSULATOR ASSEMBLY					
SR1	B6-1-003	2	SOLDER/BRAZE RING, 1/2" I.D.	P006	P008			
A2	A610-007	1	WATER TUBING ASSEMBLY					
SW1	B6-2-008	2	SOLDER WASHER, 4 63/64" O.D.	P005	P008		HYDROGEN	
SS1	G611-012	1	DEMOUNTABLE CONFLAT END PLATE				FURNACE	
SW2	B6-2-004	1	SOLDER WASHER, 1 11/32" O.D.	P005	P008		BRAZE	A611-003
SS2	G610-005	1	OPP. ELECTRODE SPACER	P013		NICKEL	PALCUSIL 15	
SW3	B6-2-005	1	SOLDER WASHER, 1/ 11/32" O.D.	P005	P008		900/850 deg. C	
SS3	G610-006	1	OPP. ELECTRODE COOLING BACKING PLA	P013		NICKEL		
SW4	B6-2-006	1	SOLDER WASHER, 2 21/64" O.D.	P005	P008			
C1	G610-007	1	OPP. ELECTRODE COOLING CHANNEL	P011	P011			
SW5	B6-2-007	2	SOLDER WASHER, 2 1/8" O.D.	P005	P008			
T1	G610-001	1	OPPOSITE MAIN ELECTRODE	P001	P008	P009		PAGE # 5

C. C. E.
CUSTOMER: NSWC
TITLE : G611 SPARK GAP
FLOW CHART G0611

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345 JOB #:
31-Jan-95 #REQUIRED:

DESIG.	DWG. NO.	QTY.	DESCRIPTION	CLEANING PROCESS	DEGREASING PROCESS	PLATING PROCESS	TYPE OF BRAZE	FINAL ASSEMBLY NO.
	G0610		FINAL SPARK GAP ASSEMBLY					
A1	A610-003 -	1	ELECT.- INSULATOR ASSEMBLY				HYDROGEN	
SW1	B6-2-013	2	SOLDER/BRAZE WASHER, 6.00" O.D.	P005	P008		FURNACE BRAZE	
SW2	B6-2-014	2	SOLDER/BRAZE WASHER, 4 31/32" O.D.	P005	P008		CUSIL	G0611
A2	A610-008	1	ADJ. ELECTRODE ASSEMBLY				780/780 deg. C	
SS1	G611-023	1	WINDOW RETAINER	P013		NICKEL		
SS2		1	37 deg. 1/4" TUBE FLARE NUT			NOTE:		
SS3		1	1/4" TUBE FLARE NUT SLEEVE			AFTER COOL DOWN, FIT FLARE NUT, FLARE SLEEVE, AND FLARE EXHAUST TUBULATION AS PER PROCESS P002.		

PROCESS SPECIFICATIONS

CLEANING TUNGSTEN-COPPER ELECTRODES P001

The electrodes should be cleaned shortly before assembly and hydrogen furnace brazing. A long delay may produce enough surface oxidation to prevent a solder from flowing properly.

1) Using finger cots, scrub the entire electrode surface with clean water and an abrasive cleaner. The abrasive cleaner <u>must be</u> chemically neutral. Rinse occasionally to check the surface. The electrode is clean when it is no longer a dark copper-gray, but a light and shiny copper- silver color.

2) Use a cotton to swab and scrub the corners and surfaces of the electrode with wet abrasive where the braze is to take place. This is to insure that the braze surface areas are particularly clean.

3) Rinse the electrode thoroughly in water. Swab Nutri-Clean over the braze area and rinse thoroughly again. Thoroughly dry the electrode.

4) Degrease the electrode in a vapor degreaser, or rinse thoroughly in trichlorethane.

5) Wrap in lint free paper.

NOTE: It may be beneficial to try vapor or sand blasting the electrode to clean it, so as to save time. Try this only with approval.

BAKE-OUT AND OUTGASING OF SPARK GAP ASSEMBLIES P002

Baking the spark gap at a higher temperature while vacuum pumping on the tubulations outgases the inside surfaces very effectively.

1) The exhaust tubulation is 1/4 inch 304 stainless steel.

2) Place a 37 deg. flared tube nut and sleeve over the exhaust tubulation. Using a flaring tool flare the end of the tubulation. Inspect the flare for cracks or imperfections in the flare.

NOTE: If any of these conditions exist cut off the flare and repeat the flaring step until correct.

3) Attach the flared gap tubulation to the 1/4 inch flare fitted vacuum port inside the bake-out oven. Tighten the flare nut to 135 in/lbs minimum to 145 in/lbs maximum torque. This fitting must be tightened correctly because of the fill gas pressures involved.

4) Set the valves to the configuration shown in MTD610-1. Turn on the mechanical roughing pump and pump down for a few minutes. Start diffusion pump and close valves as shown in MTD610-2 and allow the system to pump down to a pressure of 150um Hg, which is metered on the thermocouple gauge.

5) Brush acetone on each of the tubing connections and braze joints while looking for a jump in the thermocouple meter. Such a sudden apparent increase in pressure indicates a leak at that joint. If a leak exists, shut down the system and repair the bad joint. Restart the system according to step 4. If no leak exists, continue on.

6) Place heat shielding above and below the gap manifold to protect the spark gap from direct heat of the oven coils. Monitor the oven temperature with a standard temperature thermocouple weighted down with small scrap ceramic pieces.

7) Close the valves to the pressure gauge and fill gas regulator as shown in MTD610-3.
Plug the oven in and turn on. Set the temperature to 520 degrees C for the Tungsten-Copper electrodes.
The oven will begin to warm up and must be watched closely after about 25 minutes.

8) When the desired temperature has been reached allow the gap to bake while being pumped for one hour, checking the temperature every 10-15 minutes. The temperature should remain within plus/minus 20 degrees C of the desired temperature.

9) While still maintaining a constant temperature as above, close the manifold valve going to the diffusion pump and open the air valve as per drawing MTD610-4. This allows air inside the gap and the electrode surfaces to oxidize at high temperature. Every 5 minutes the air valve should be closed, and the system re-evacuated in the 2 step procedure shown in MTD610-5 and MTD610-6. Then fresh

air re-introduced as per drawing MTD610-4 in order to maintain a constant supply of oxygen and water vapor to the electrode surfaces. After 30 minutes of this process oxidize and close off the air valve. Turn off and unplug the oven. Spark gaps with molybdenum electrodes or parts must not be left at low pressure during cooling (after oxidation) as the molybdenum oxide has a high vapor pressure in vacuum.

10) At temperatures below 300 degrees C the oven door may be opened slightly to expedite cooling.

The gap must be cooled to within 5 degrees C of room temperature before continuing.

NOTE:

a) The gap must be supported with plastic or ceramic.

b) Phenolic should be used to insulate the oven rack and heater coils from spurious arcs/corona. Electrical tape may be used for securing the phenolic.

1) Install a 10k-100k ohm 2W resistor from the trigger to the adjacent electrode. This prevents arcing from the trigger electrode from occurring.

2) Assemble the circuit shown in MDT610-15. If a voltage greater than 100kV is to be used, a plexiglass cover should be installed and the high voltage leads inserted through the center and bottom holes. Purge the oven volume with freon 12, which is available through refrigeration and plumbing supply distributors. Be sure all high voltage leads are supported properly and all grounds are connected. Make sure oven is unplugged.

3) Evacuate the spark gap manifold as per drawings MDT610-5 and MDT610-6, and purge twice with the fill gas mixture.

4) Close off all valves to the vacuum pumps and vacuum gauge. Fill the spark gap with the hydrogen gas to the projected fill pressure using the procedure and valve configuration found on drawings MDT610-7 and MDT610-8.

5) Turn the high voltage on and increase the potential. Using the steps shown on drawing MDT610-9 continue on. If no breakdown occurs at a "reasonably low" voltage, decrease the pressure. If static breakdown occurs at too low of a voltage, increase the pressure. It is often helpful to age the gap about 20 shots at about 15% higher SBV than desired and then adjust to the necessary lower SBV.

6) When the gap fires reliably at the desired SBV, about 10 times, the gap may be removed from the manifold. Turn off the high voltage power supply and ground the charging capacitor. Leave the grounding stick hooked to the on the capacitor. At this point refer to drawing MTD610-10 for valve configuration and instructions. Remove all voltage connections to the gap and polish the end of the tubulation with steel wool. Leave a long tubulation in case repumping is necessary. Oil the tubulation and pinch-off tool rollers with castor oil. While supporting the gap, pinch the tubulation in the polished area with a smooth and powerful squeeze of the pinch-off tool. The gap should be loose without pulling or twisting it. Label the gap with a paper tag to identify it's SBV.

ELECTRICAL TESTING OF THE SPARK GAP P004

NOTE: Refer to Table 1 for calibration of the trigger unit.

1) Assemble the circuit as shown in drawing MTD610-16.

2) With the trigger unit off, check to be sure the SBV is correct. (if possible)

3) Measure the minimum electrode to electrode breakdown voltage (e-e min). Turn the trigger unit on and adjust the voltage to 100kV. Turn on the main power supply and slowly increase the voltage across the spark gap. While occasionally triggering, find the voltage for which the gap will trigger and conduct. Record the voltage at and above the point at which the gap will always conduct. Below this voltage the gap should fire only intermittently. This voltage is the e-e min voltage.

4) Measure the minimum trigger voltage necessary to cause a breakdown across the gap, (t min). At e-e min trigger the gap at consecutively lower trigger voltages. When the gap will no longer fire when triggered, increase the trigger voltage till it does. If the gap fires reliably (about 10 times) at this voltage and will not fire at any lower trigger voltage, record the trigger voltage as the minimum trigger voltage, (t min).

5) Record any odd behavior.

MAKING SOLDER/BRAZE WASHERS **P005**

Most solder washers to date have been made by hand. Much care must be taken in order to insure the washers do not suffer from being handled to heavily and deforming them to the point of being useless.

1) Adjust the knife edge slide rule compass to the desired radius corresponding to the washer's outside diameter. Care must be taken at this point, double check the scale on the slide rule compass with another scale, as the scale on the slide rule compass might read over slightly.

2) With the solder stock on heavy cardboard on a table, center the compass on the solder and scribe a cutting line heavily into the solder stock. Scribe all the outside diameters of all the solder washers of this size that are needed.

3) Cut the washers out carefully with a small pair of scissors. The more accurately they are cut out, the more likely they will fit the work without modification.

4) Readjust the compass for the radius corresponding to the inside diameter of the washer. Use the same center hole of the solder disk and scribe a cutting line for the inside diameter. Scribe all disks which use this size at the same time.

5) Cut along the inside line with an "Exacto" knife enough to get the tips of the small scissors in, then carefully cut the rest of the way with the scissors.

6) Flatten each solder washer by rubbing it down on a hard surface with the back of a pair of tweezers. Check each solder washer to be sure it fits the work it is intended for. They must fit without bending or buckling, and must not be very loose. Vapor degrease them.

NOTES:

a) BT/CUSIL solder is soft and will bend very easily.

b) Palcusil solder, or its equivalent, is very hard and is difficult to flatten out. Care must be taken not to bend it sharply.

c) Subassemblies use Palcusil solder. Final assemblies use BT/CUSIL solder.

d) Save and identify all scrap solder.

SOLDER RINGS P006

Solder rings to date have been made by hand. It requires a minimum of tools but a maximum of patience. So far only Palcusil 25 has been made into rings.

For small rings which go onto the exhaust tubulation:

1) Use a dowel slightly smaller than 0.25 inches, such as a drill bit or a small screwdriver shank and wrap the wire tightly onto it.

2) The coil should spring back some. Try to fit it onto a tubulation. If it fits cut rings into groups of three (3). If they are too small cut them off and stretch them one by one. There should not be any gaps in the ring when it fits onto the tubulation. If the rings are too big, under cut them one by one and squeeze them down to the right diameter. The rings must fit snugly against the tubulation and not have any gaps between the ends of the rings.

For larger that fit next to the tubulation disc and flange:

1) Use a dowel as above but find one that is about 0.6-0.7 inches in diameter. Wrap the wire tightly onto it. When the coil is removed it will spring back to a larger but variable diameter.

2) Cut off enough of the coil to make a ring to fit. Carefully work with the ring to increase or decrease its diameter to fit into the flange hole. It must fit squarely with a small amount of spring (but not too much), be very flat, and have no gap where the ends meet (although they may overlap slightly).

3) Degrease the finished solder rings.

LEAK CHECKING

P007

Leak checking has been done on a Veeco brand helium leak detector with a variety of fixtures. A plate about 12 inches square with a silicon rubber sheet on top and a 1/4 inch copper tube on the bottom has been most useful in leak checking. Use silicon vacuum grease sparingly on rubber seals to form a good seal.

1) If there is an obvious defect in the assembly which will cause a vacuum leak re-braze the defect before continuing the leak check.

2) Place the flange upside down on the fixture. Plug the electrode hole (if applicable) with a rubber stopper. Evacuate the assembly and proceed checking for leaks according to the leak detector's specific directions.

3) If problems with seals are encountered and leak checking cannot be done reliably, brushing acetone around edges, cracks and other suspect areas will plug the leak long enough to leak check the brazes on the rest of the flange. Care must be taken not to get acetone in areas where a check is wanted, as a false reading will be given.

4) When a definite result is obtained remove the flange from the fixture and:

   a) For opposite flanges, turn it upside down to check for leaks in the opposite direction.

   b) For adjacent flanges, continue on.

5) Clean the flange with acetone and then vapor degrease. No silicon grease may remain on the flange. Wrap the flange in lint free paper and store until needed. Label the flange with a paper tag if it is not easily identified.

VAPOR DEGREASING P008

1) The part to be degreased should not be to dirty. Remove any obvious dirt, dust or grease with a paper towel and solvent. Doing this helps insure a thorough cleaning of the parts over a long period of time.

2) Hang the parts on a hook, or place them in a basket. Place the parts in the degreaser for about 5 minutes. If there are a lot of parts in the degreaser at the same time, allow them to remain there for about 10 minutes or longer to be sure of a good cleaning.

3) Remove the parts and dry them under forced air. Wrap them in lint free paper and store until needed.

CHEMICAL ETCHING OF TUNGSTEN-COPPER ELECTRODES P009

The surface of tungsten-copper electrodes have sometimes been acid etched to remove the surface copper and hence reduce wall sputtering. The etching is done on the flange assembly to facilitate holding.

1) Make an acid bath of:

25ml Hydrofloric Acid
125ml Nitric Acid
480ml Distilled Water

2) Don appropriate safety equipment (i.e. gloves, face shield and apron). Carefully swab with cotton swabs, or a cotton ball and a small wire brush the acid mixture over the surface of the electrode. Do not swab the braze area. Acid mixture must not run onto braze areas or the flange.

3) Continue swabbing the surface for about 30 minutes or until the electrode no longer has a copper color to it.

4) Rinse the flange assembly in hot water, then in acetone and dry under forced air. Wrap the flange assembly in lint free paper until it is needed.

NOTE: Try, with approval only, a stronger acid mixture

50ml Hydrofloric Acid
250ml Nitric Acid
500ml Distilled Water

TUBULATION CAP OF THE SPARK GAP P010

After pinching the spark gap off and performing the electrical testing, the tubulation must have a small copper cap soldered onto the end so as to protect the seal against breaking. The tools needed are as follows:

Propane torch and igniter
Fire brick
Needle nose pliers
Good quality rosin core solder
Triclorethane

1) Large spark gaps may have long tubulations, small spark gaps must have tubulations as short as possible.

2) Clean the end of the tubulation with the triclorethane. The tubulation on large spark gaps should be straightened out for now.
NOTE: DANGER! Because of the flammable nature of triclorethane it <u>must be</u> put away before proceeding with the next step.

3) Heat up the fire brick with the torch. Place the copper cap on the hot portion of the fire brick. Melt solder inside the cap, heating with torch as necessary. Do not over heat the copper cap as it is very thin and will oxidize away very easily.

4) Dip the end of the tubulation into the cap and molted solder. Make sure the cap is on straight with respect to the tubulation. Allow the solder to solidify before moving the tubulation.

5) Scrape off the worst of the solder flux. Check the neatness of the soldering and cap alignment. On large spark gaps curl the tubulation under the surface of the flange.

NOTE:
If the rosin core solder will not flow, clean the parts and use some stainless steel solder flux.

COPPER CLEANING P011

1) Copper is cleaned using BCB COPPER CLEANER. Clean the copper parts according to the cleaner's packaged instructions. This cleaner is available through:

Hubbard-Hall, Inc.
563 S. Leonard St.
Waterbury, Ct 06725
Phone (203) 756-5521

MOLYBDENUM AND TUNGSTEN CLEANING PROCESS P012

Molybdenum and tungsten use the same cleaning process.

1) Vapor degrease the parts as per instruction P008.

2) Very dirty oxidized parts must be vapor blasted and degreased.

3) Mix a 33% Potassium Hydroxide (KOH) and distilled water solution.

4) Connect a positive 6 volt power supply to the molybdenum parts and submerge them in the KOH solution. Molybdenum parts are the positive electrode, and a carbon electrode is the negative electrode. Turn the power supply on until the parts are a bright silver-gray.

NOTE:

a) Other negative electrode materials might be used with approval.

b) Only small amounts of current are necessary. Use a current limiting resistor when appropriate.

5) Rinse and dry the parts in the following sequence:

Cold water
Hot water
Acetone
Dry under hot forced air

6) Wrap the parts in lint free paper and store until needed.

CLEANING OF STAINLESS STEEL PARTS PO13

All stainless steel parts should be cleaned shortly before assembly. This will prevent any dust, oils, or other substances from contaminating any surfaces that are weld, or braze joints.

1) Inspect parts to be cleaned. Check parts for any material left from the milling process (ie.. filings or shavings). Using a lint free cloth wipe off any particles before proceeding.

2) Prepare a hot alkali degreasing solution as follows:

    a) Use DIVERSEY WYANDOTTE MAXAMP cleaner.

    b) Dissolve 8 ounces/gallon of cleaner into deionized water heated to 50 degrees C.

    c) Heat solution to between 70-80 degrees C.

    d) Clean anodically at 80-100 amps/square foot for 30-90 seconds.

3) Rinse for 1 minute in deionized water.

4) Rinse in methanol.

5) Dry in hot oven.

6) Dip parts in a 50% by volume solution of hydrocloric acid for approximately 5 minutes.

7) Rinse in deionized water.

8) Dry in hot oven.

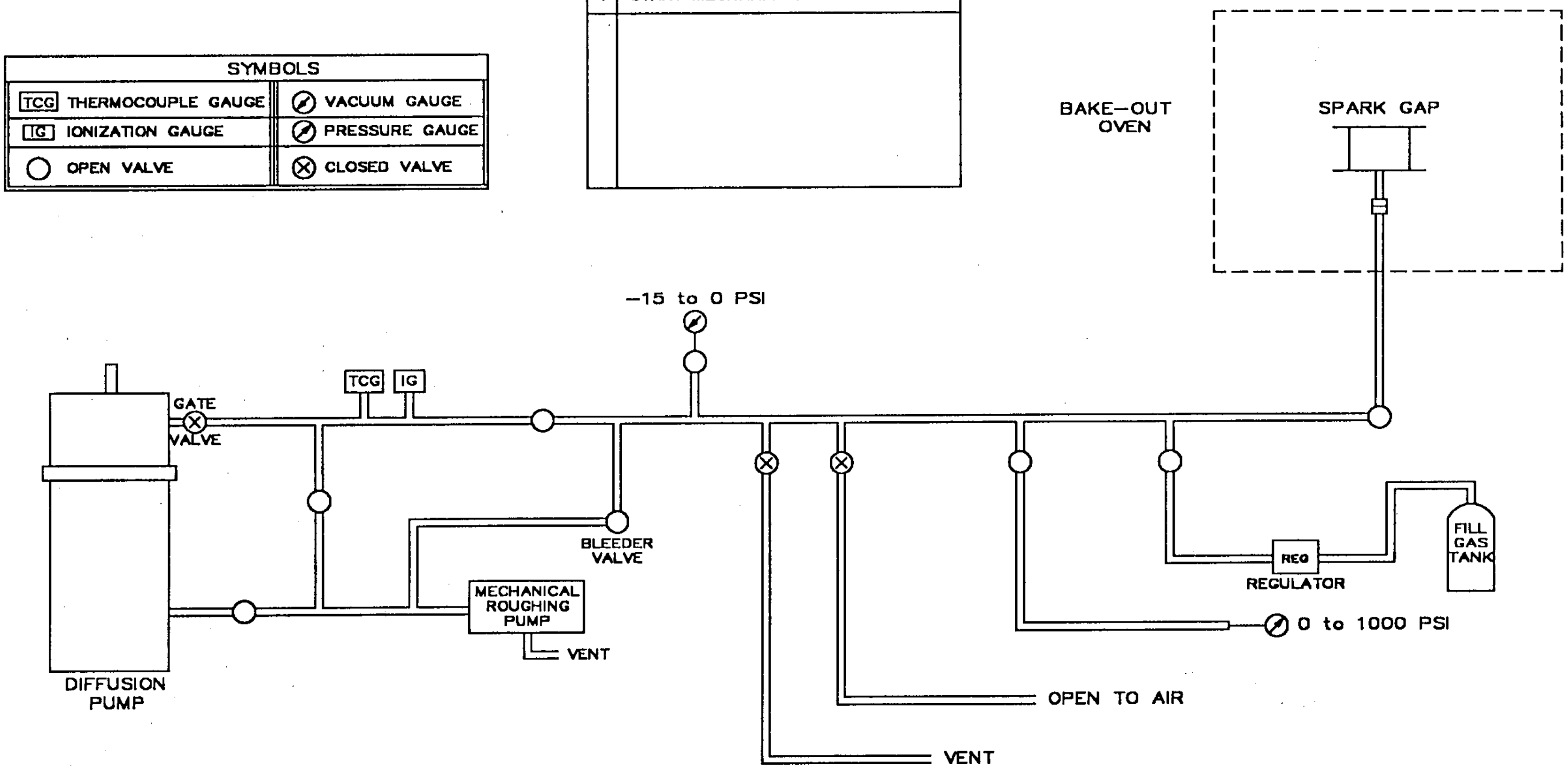
9) Wrap in lint free paper, package carefully, and send to proccesser for nickel plating.

NOTE:
This proccess does not apply to any conflat flanges, as it could destroy the knife edge on the flange.

SYSTEM START-UP, AND ROUGH OUT

NOTES:

1	START MECHANICAL ROUGHING PUMP



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

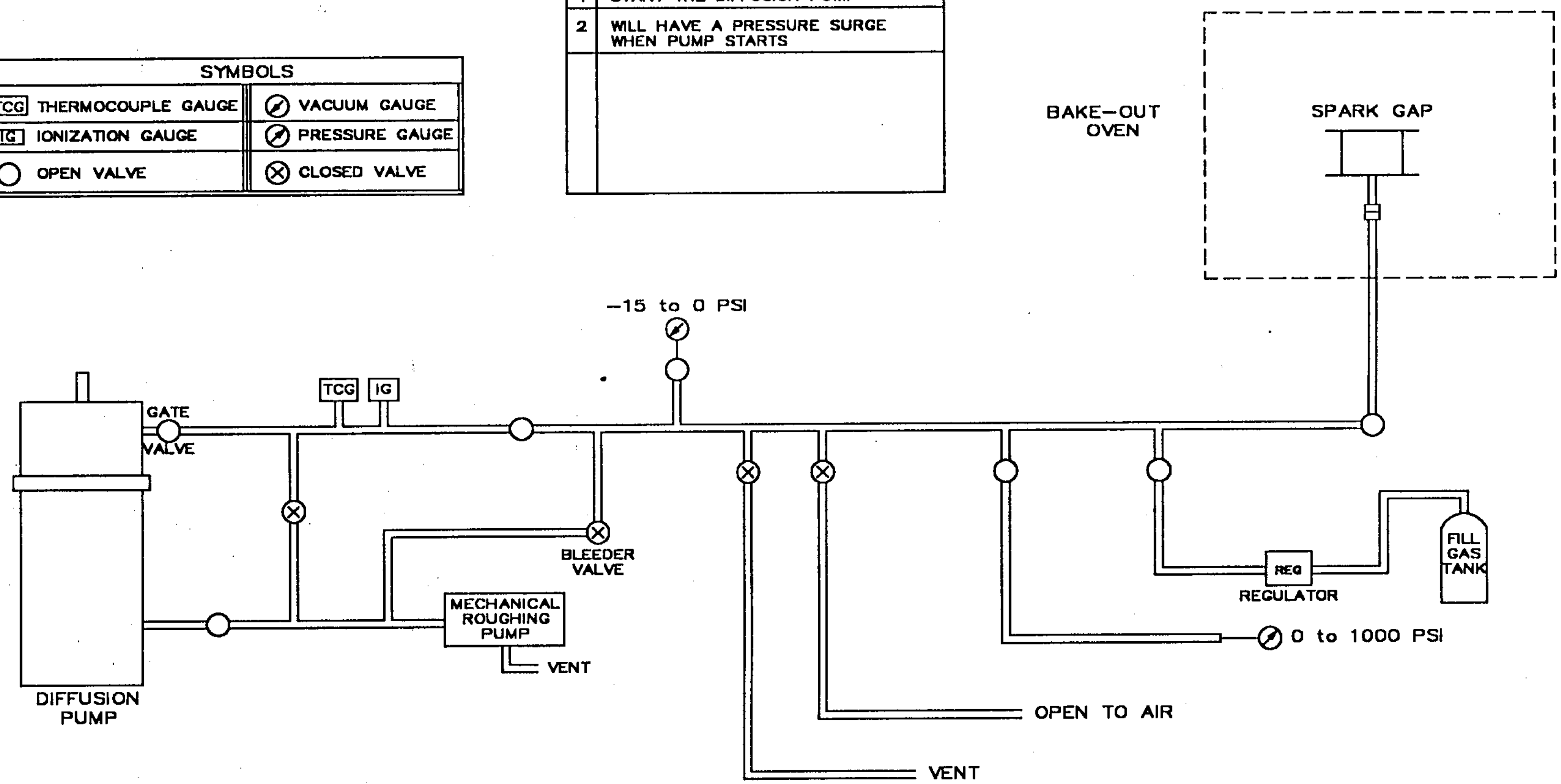
REFERENCE ONLY	
PART NO. / NEXT ASSY. / USED ON	APPLICATION
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES	
TOLERANCES OF FRACTIONS ±1/64	
TOLERANCES OF DECIMALS	.X ±0.01 / .XX ±0.005 / ∠±0.5°
1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES	
DRAWN	B.W.W. 12-94
CHKR	
APPD	
CONTRACT/JOB NUMBER	N60921-94-C-A345
	C. C. E.
	GAP PRESSURIZING SEQUENCE
SIZE / CAGECD	0Z887
DRAWING NO.	MDT610-1
REV	A
SCALE	N/A
WEIGHT	
SHEET	1 OF 14

HIGH VACUUM EXHAUST

NOTES:

1	START THE DIFFUSION PUMP
2	WILL HAVE A PRESSURE SURGE WHEN PUMP STARTS

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECO 0Z887	DRAWING NO. MDT610- 2	REV A
SCALE N/A	WEIGHT	SHEET 2 OF 14	

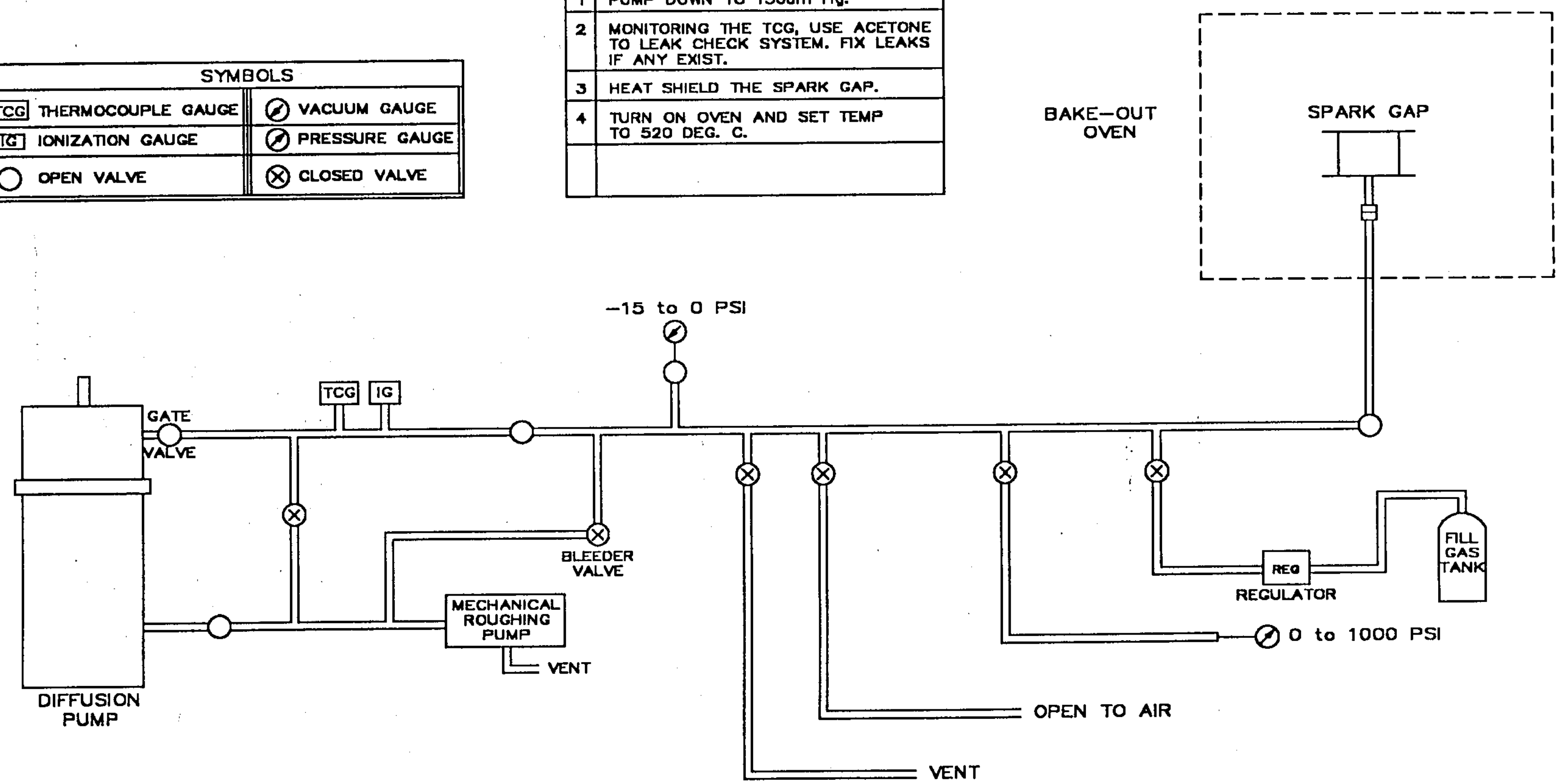
REVISIONS			
LTR	DESCRIPTION	DATE	APVD

BAKE–OUT SEQUENCE

NOTES:

1	PUMP DOWN TO 150um Hg.
2	MONITORING THE TCG, USE ACETONE TO LEAK CHECK SYSTEM. FIX LEAKS IF ANY EXIST.
3	HEAT SHIELD THE SPARK GAP.
4	TURN ON OVEN AND SET TEMP TO 520 DEG. C.

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY		
PART NO. NEXT ASSY. APPLICATION		USED ON

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

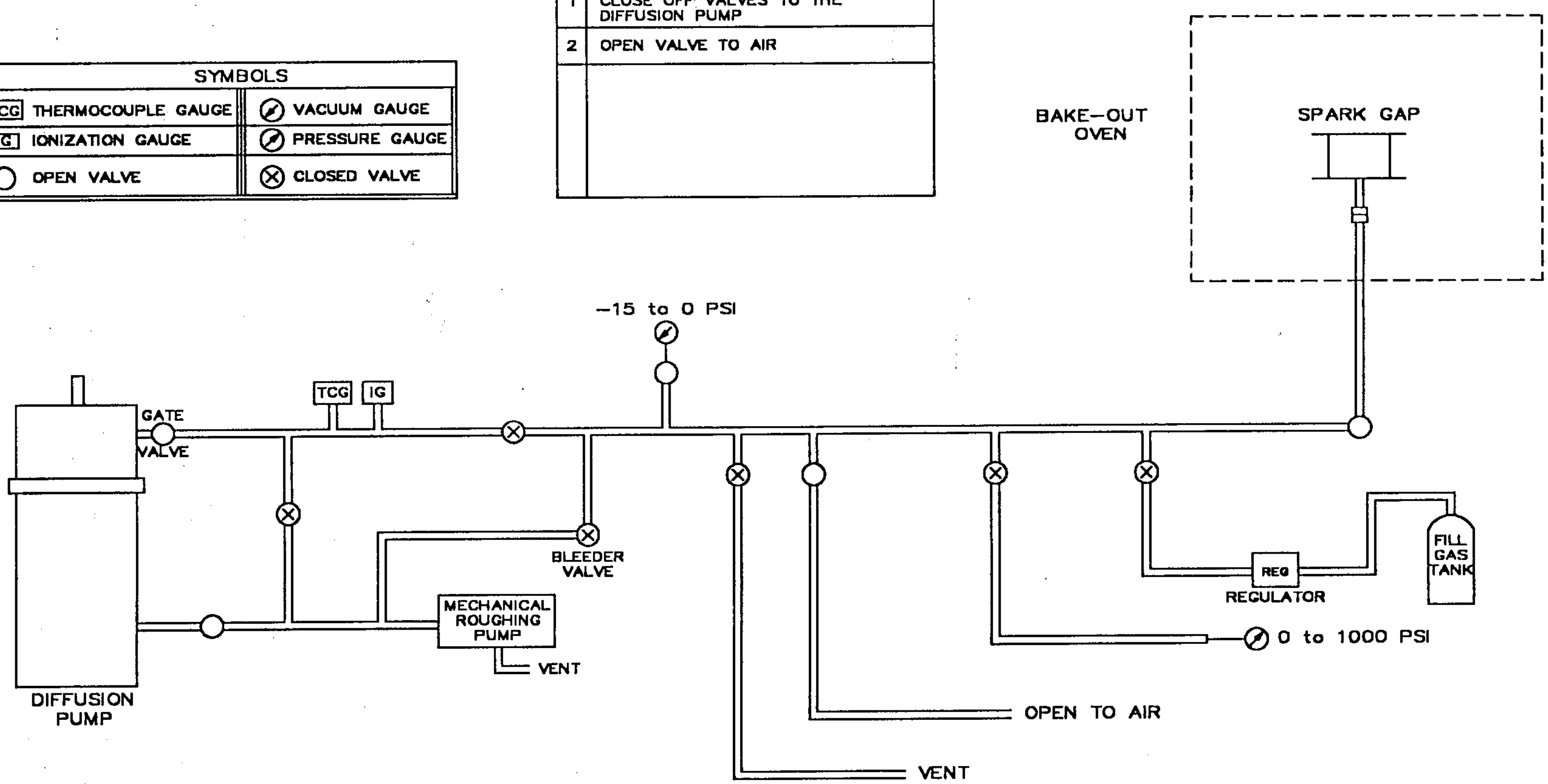
GAP PRESSURIZING SEQUENCE

SIZE	CAGECD 0Z887	DRAWING NO. MDT610-3	REV A
SCALE N/A	WEIGHT	SHEET 3 OF 14	

OXIDIZING SEQUENCE
NOTES:

1	CLOSE OFF VALVES TO THE DIFFUSION PUMP
2	OPEN VALVE TO AIR

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

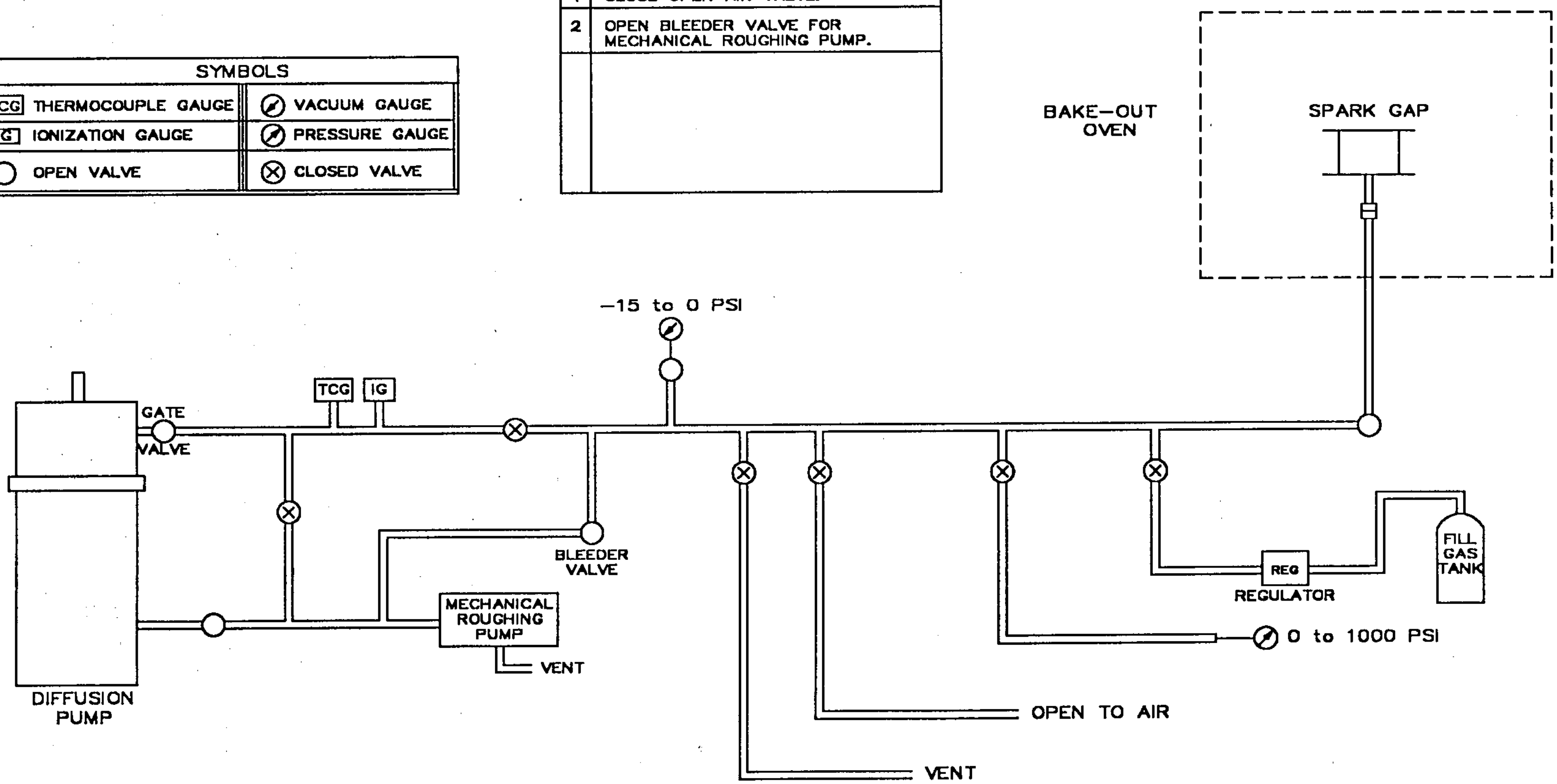
SIZE	CAGE CD 0Z887	DRAWING NO. MDT610-4	REV A
SCALE N/A		WEIGHT	SHEET 4 OF 14

RE-EVACUATING SYSTEM STEP 1

NOTES:

1	CLOSE OPEN AIR VALVE.
2	OPEN BLEEDER VALVE FOR MECHANICAL ROUGHING PUMP.

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
○ OPEN VALVE	⊗ CLOSED VALVE



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.V.V.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER
N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECD 0Z887	DRAWING NO. MDT610-5	REV A
SCALE N/A	WEIGHT	SHEET 5 OF 14	

REVISIONS	
LTR	DESCRIPTION	DATE	APVD

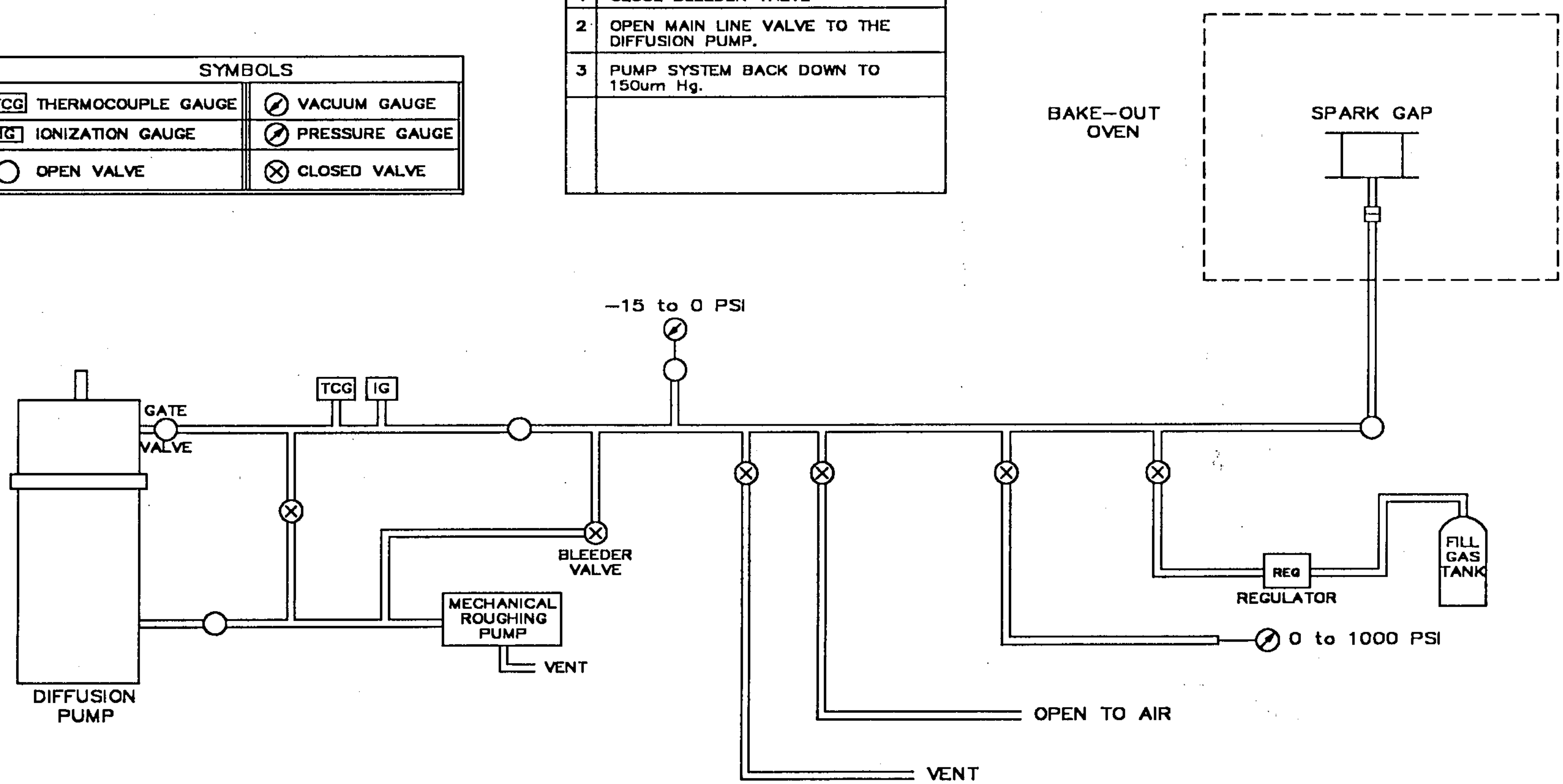
RE–EVACUATING SYSTEM STEP 2

NOTES:

1	CLOSE BLEEDER VALVE
2	OPEN MAIN LINE VALVE TO THE DIFFUSION PUMP.
3	PUMP SYSTEM BACK DOWN TO 150um Hg.

SYMBOLS

TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES		DATE	C. C. E.	
	TOLERANCES OF FRACTIONS ±1/64	DRAWN B.W.V.	12-94	GAP PRESSURIZING SEQUENCE	
	TOLERANCES OF DECIMALS	CHKR			
	.X ±0.01 | .XX ±0.005 | ∠±0.5°	APPD			
	1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.	CONTRACT/JOB NUMBER N60921-94-C-A345		SIZE | CAGECD 0Z887 | DRAWING NO. MDT610- 6	REV A
PART NO. | NEXT ASSY. | USED ON APPLICATION				SCALE N/A | WEIGHT	SHEET 8 OF 14

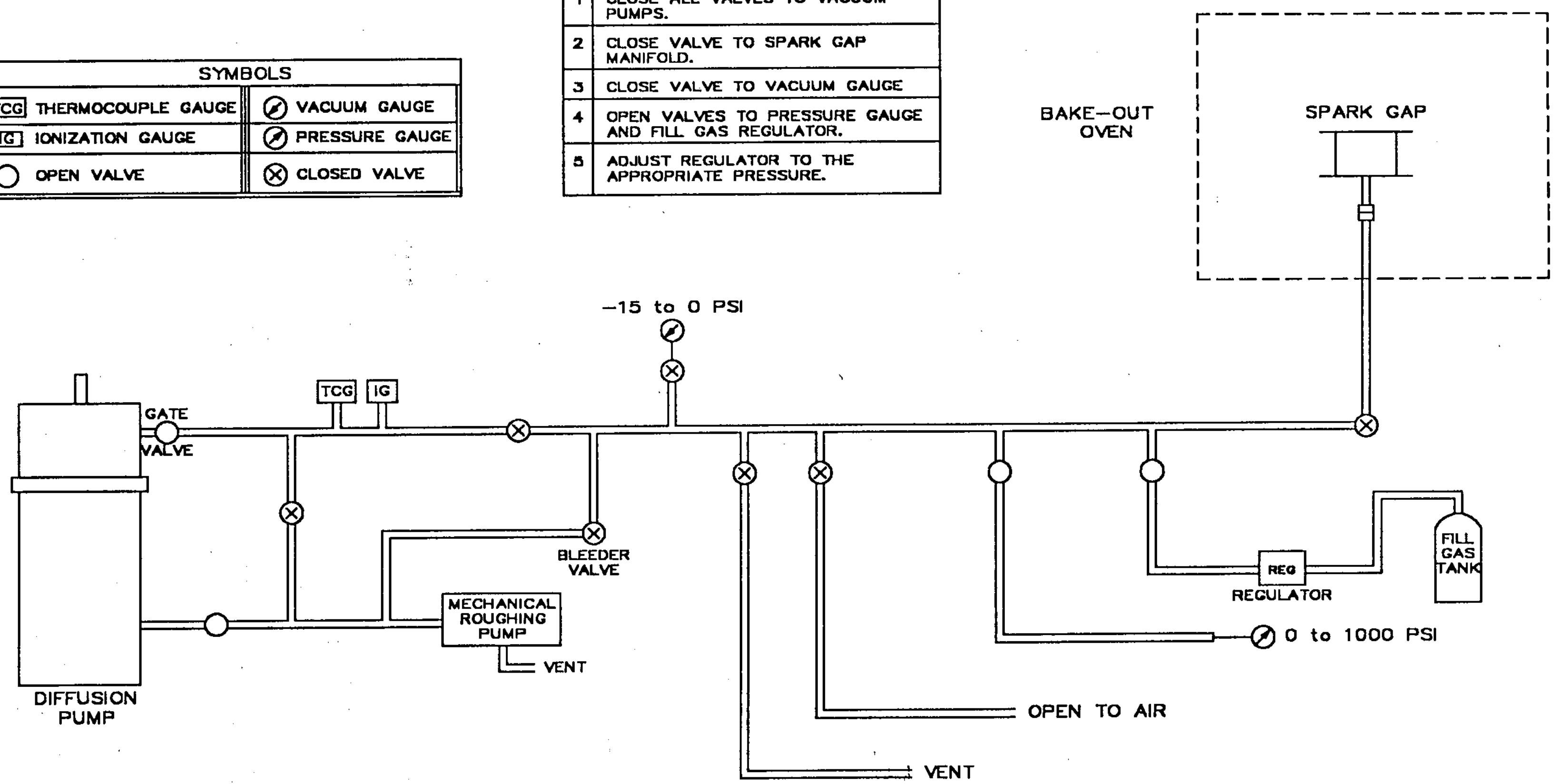
SPARK GAP FILL STEP 1

NOTES:

1	CLOSE ALL VALVES TO VACUUM PUMPS.
2	CLOSE VALVE TO SPARK GAP MANIFOLD.
3	CLOSE VALVE TO VACUUM GAUGE
4	OPEN VALVES TO PRESSURE GAUGE AND FILL GAS REGULATOR.
5	ADJUST REGULATOR TO THE APPROPRIATE PRESSURE.

SYMBOLS

TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY			
PART NO.	NEXT ASSY.	USED ON	
APPLICATION			

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 .XX ±0.005 ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECD 0Z887	DRAWING NO. MDT610-7	REV A
SCALE N/A		WEIGHT	SHEET 7 OF 14

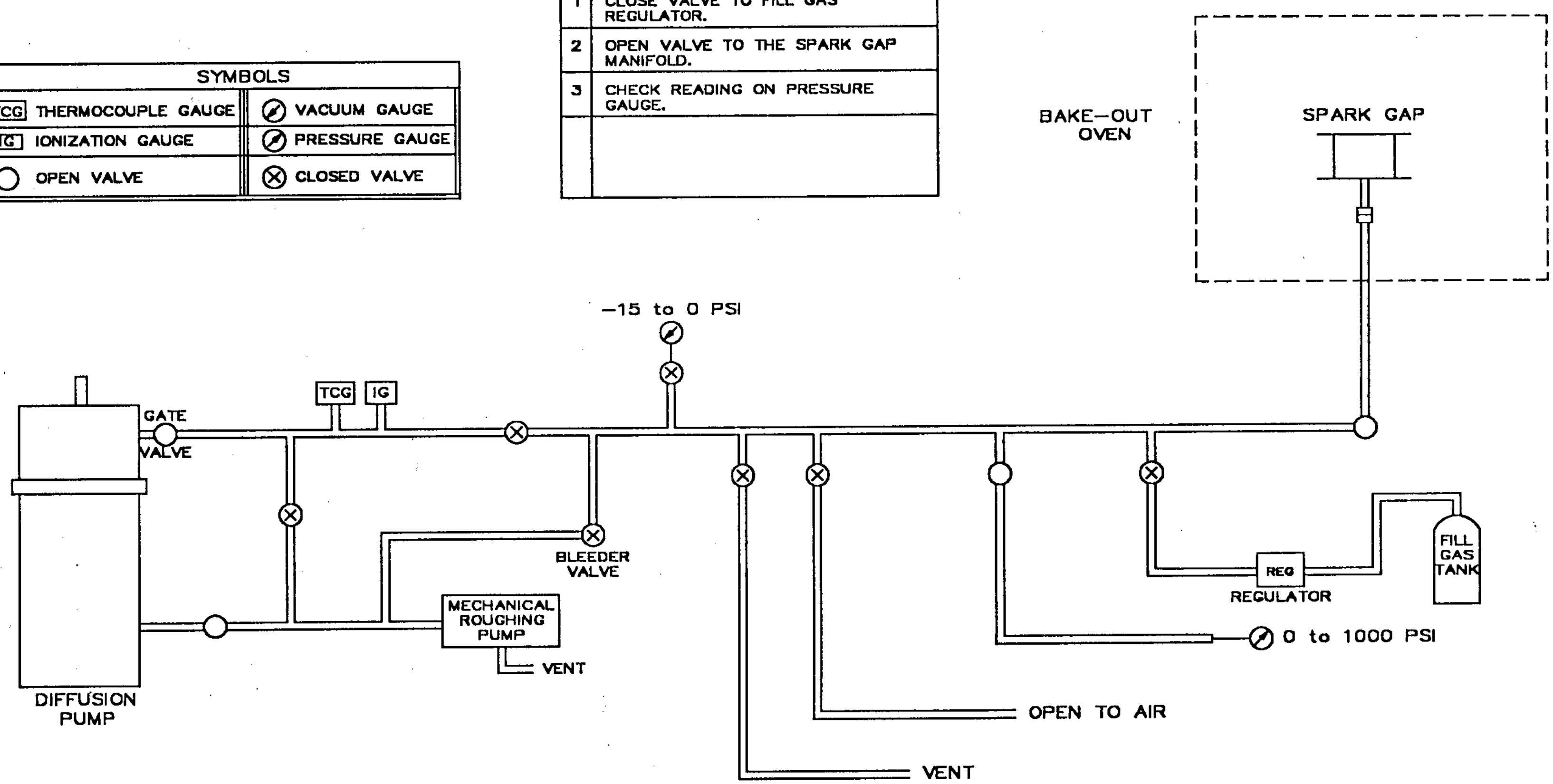
REVISIONS			
LTR	DESCRIPTION	DATE	APVD

SPARK GAP FILL STEP 2

NOTES:

1	CLOSE VALVE TO FILL GAS REGULATOR.
2	OPEN VALVE TO THE SPARK GAP MANIFOLD.
3	CHECK READING ON PRESSURE GAUGE.

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 .XXX ±0.005 ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.V.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

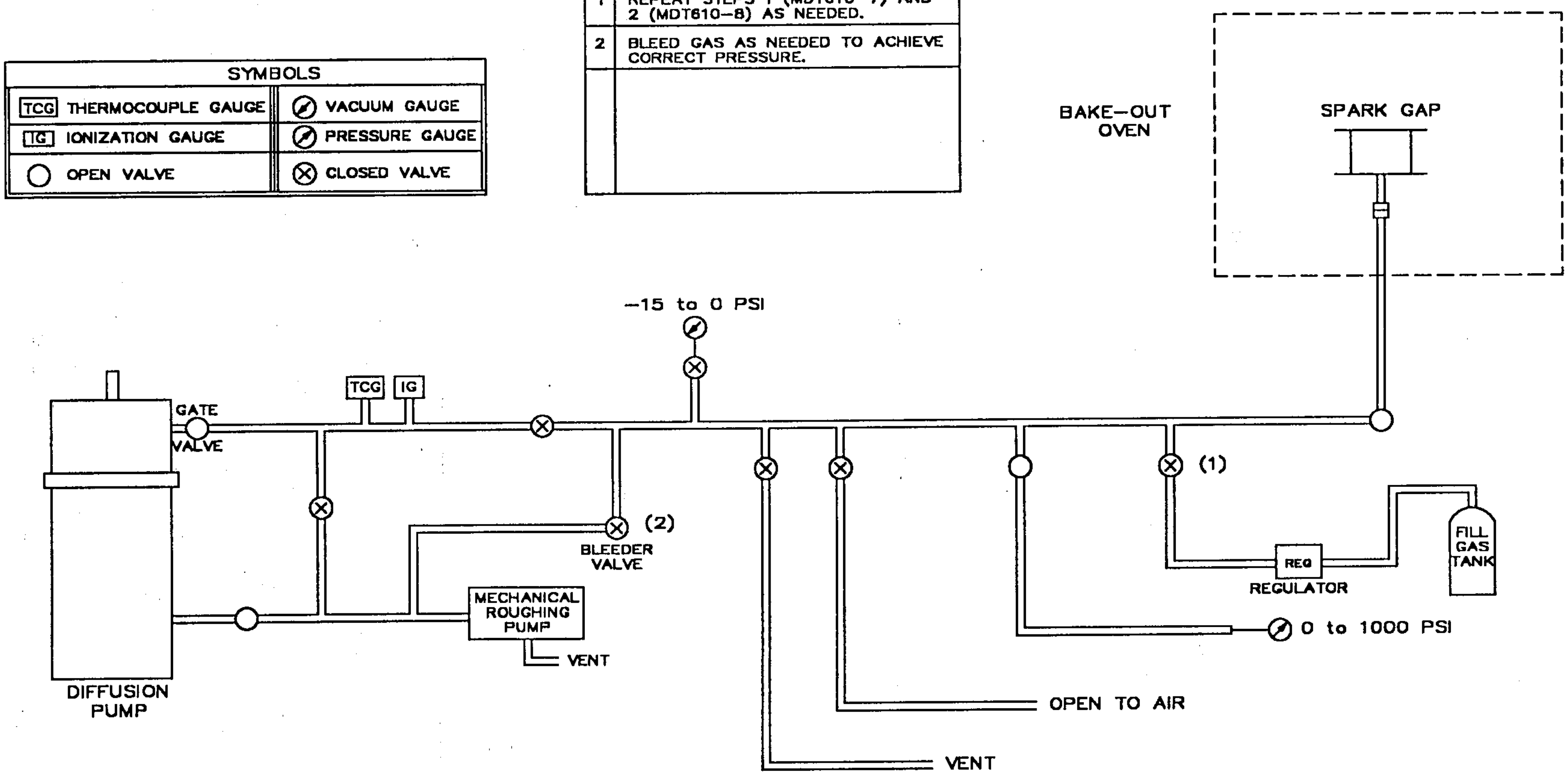
GAP PRESSURIZING SEQUENCE

SIZE	CAGECO 0Z887	DRAWING NO. MDT610-8	REV A
SCALE N/A	WEIGHT	SHEET 8 OF 14	

SPARK GAP FILL STEP 3 (ADJUST)

NOTES:

1	REPEAT STEPS 1 (MDT610-7) AND 2 (MDT610-8) AS NEEDED.
2	BLEED GAS AS NEEDED TO ACHIEVE CORRECT PRESSURE.



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECO	DRAWING NO.	REV
	0Z887	MDT610- 9	A

SCALE N/A | WEIGHT | SHEET 9 OF 14

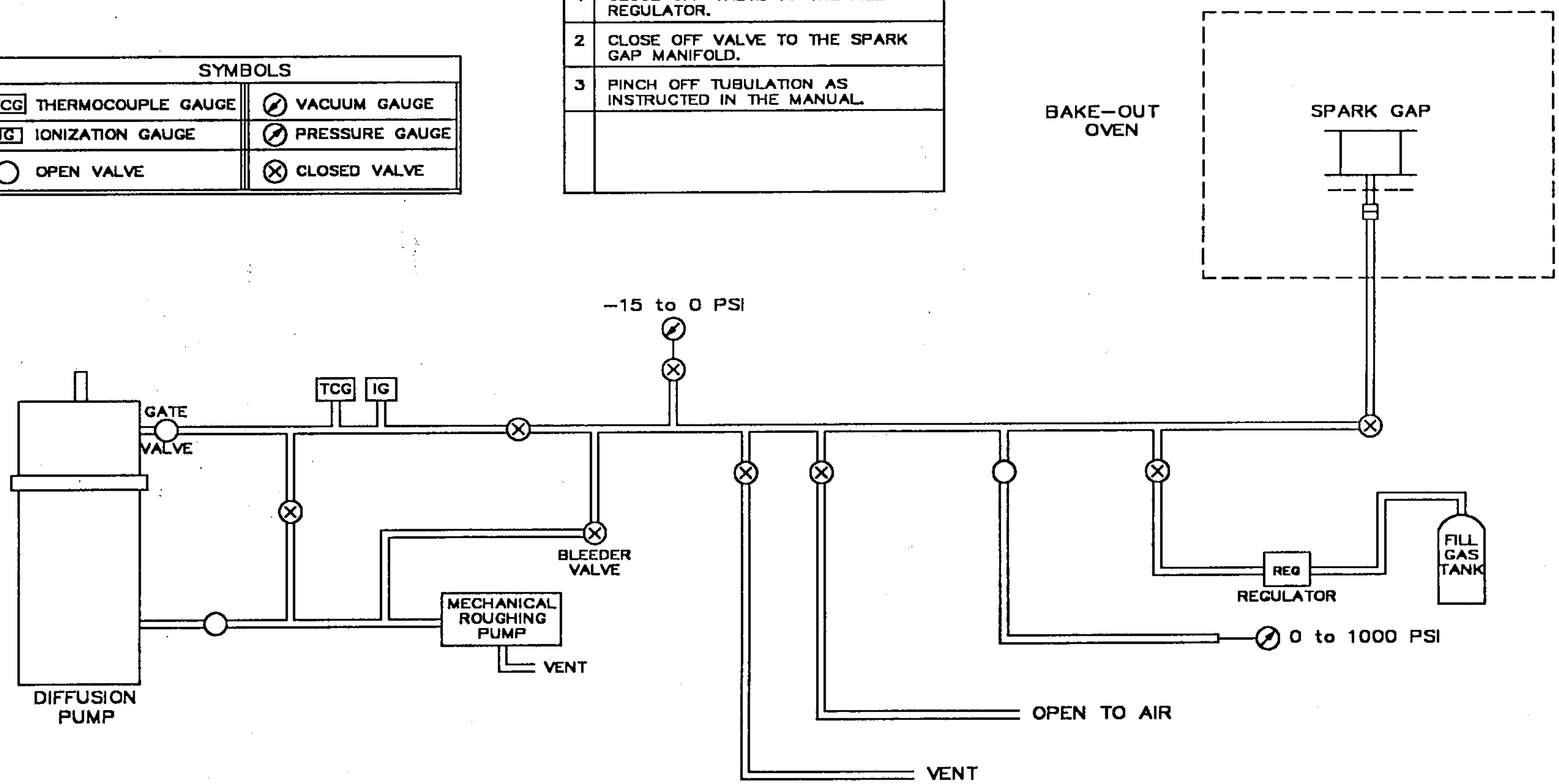
REVISIONS			
LTR	DESCRIPTION	DATE	APVD

SPARK GAP TUBULATION PINCH-OFF

NOTES:

1	CLOSE OFF VALVE TO THE FILL GAS REGULATOR.
2	CLOSE OFF VALVE TO THE SPARK GAP MANIFOLD.
3	PINCH OFF TUBULATION AS INSTRUCTED IN THE MANUAL.

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. √

		DATE
DRAWN	B.W.V.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGE CODE	DRAWING NO.	REV
	0Z887	MDT610-10	A
SCALE N/A		WEIGHT	SHEET 10 OF 14

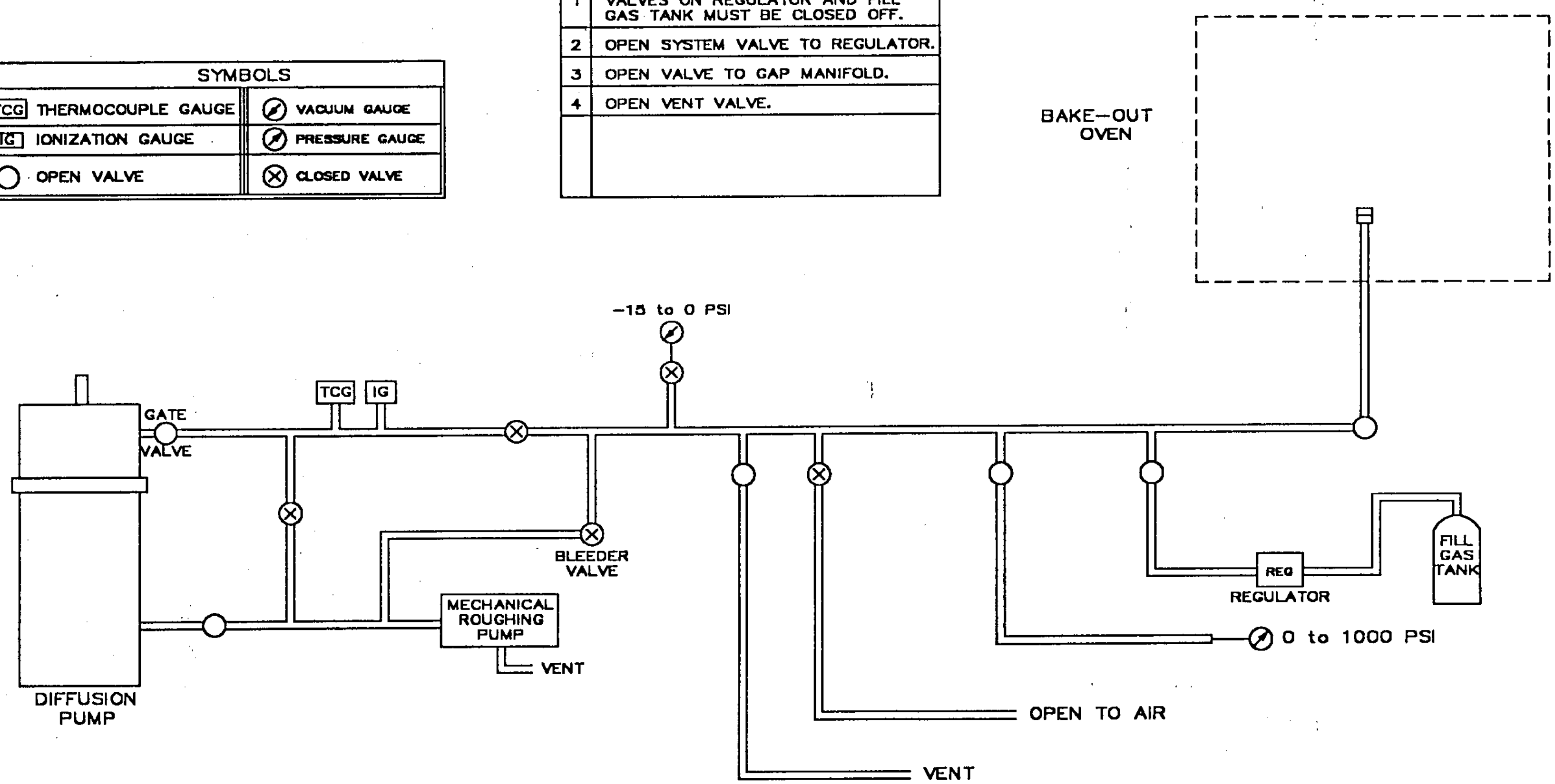
SYMBOLS

TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE

SYSTEM VENT

NOTES:

1	VALVES ON REGULATOR AND FILL GAS TANK MUST BE CLOSED OFF.
2	OPEN SYSTEM VALVE TO REGULATOR.
3	OPEN VALVE TO GAP MANIFOLD.
4	OPEN VENT VALVE.



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∢±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECD	DRAWING NO.	REV
	0Z887	MDT610-11	A
SCALE N/A		WEIGHT	SHEET 11 OF 14

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

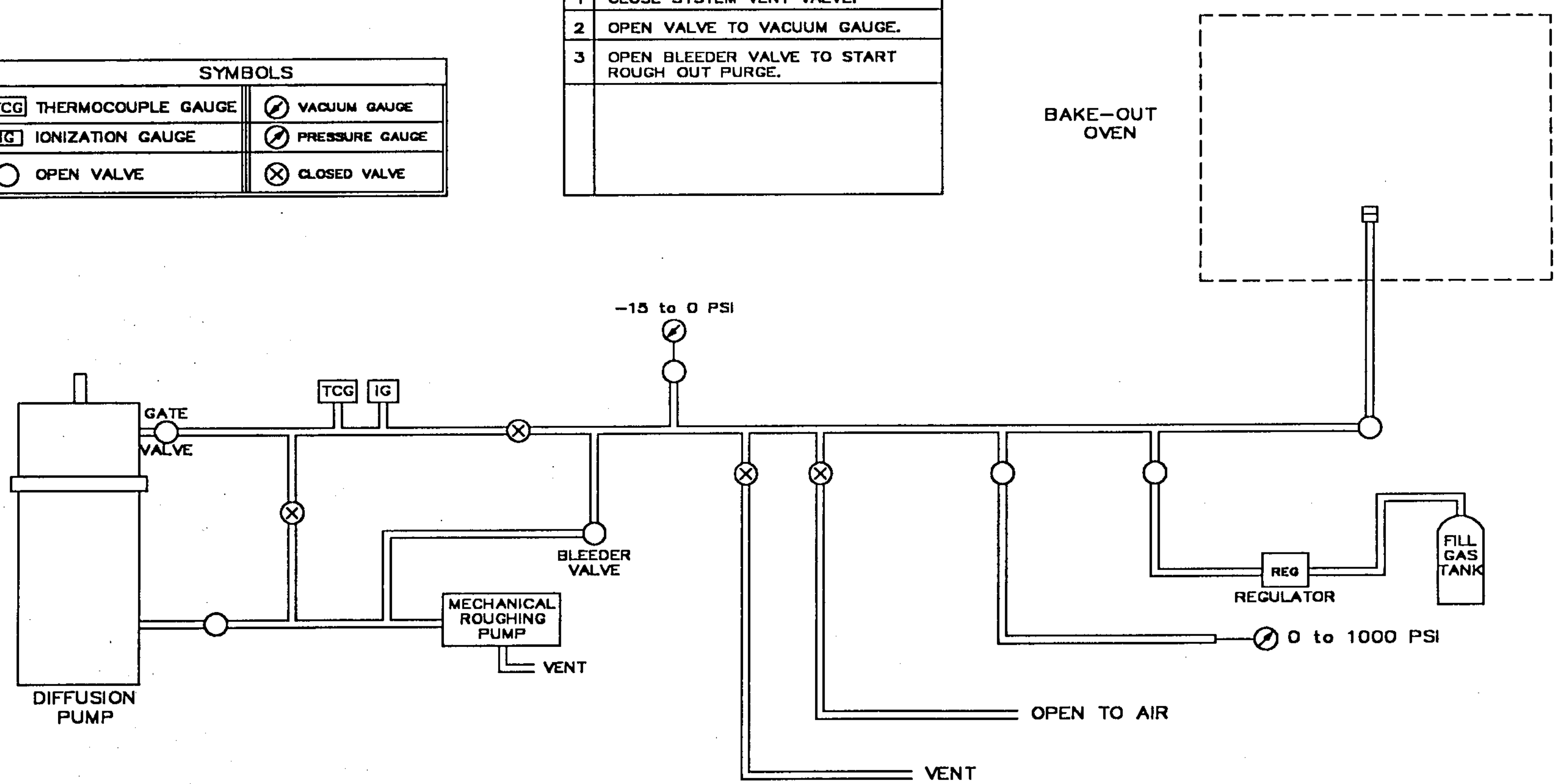
SYSTEM PURGE STEP 1

NOTES:

1	CLOSE SYSTEM VENT VALVE.
2	OPEN VALVE TO VACUUM GAUGE.
3	OPEN BLEEDER VALVE TO START ROUGH OUT PURGE.

SYMBOLS

TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.V.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE	CAGECD 0Z887	DRAWING NO. MDT610-12	REV A
SCALE N/A		WEIGHT	SHEET 12 OF 14

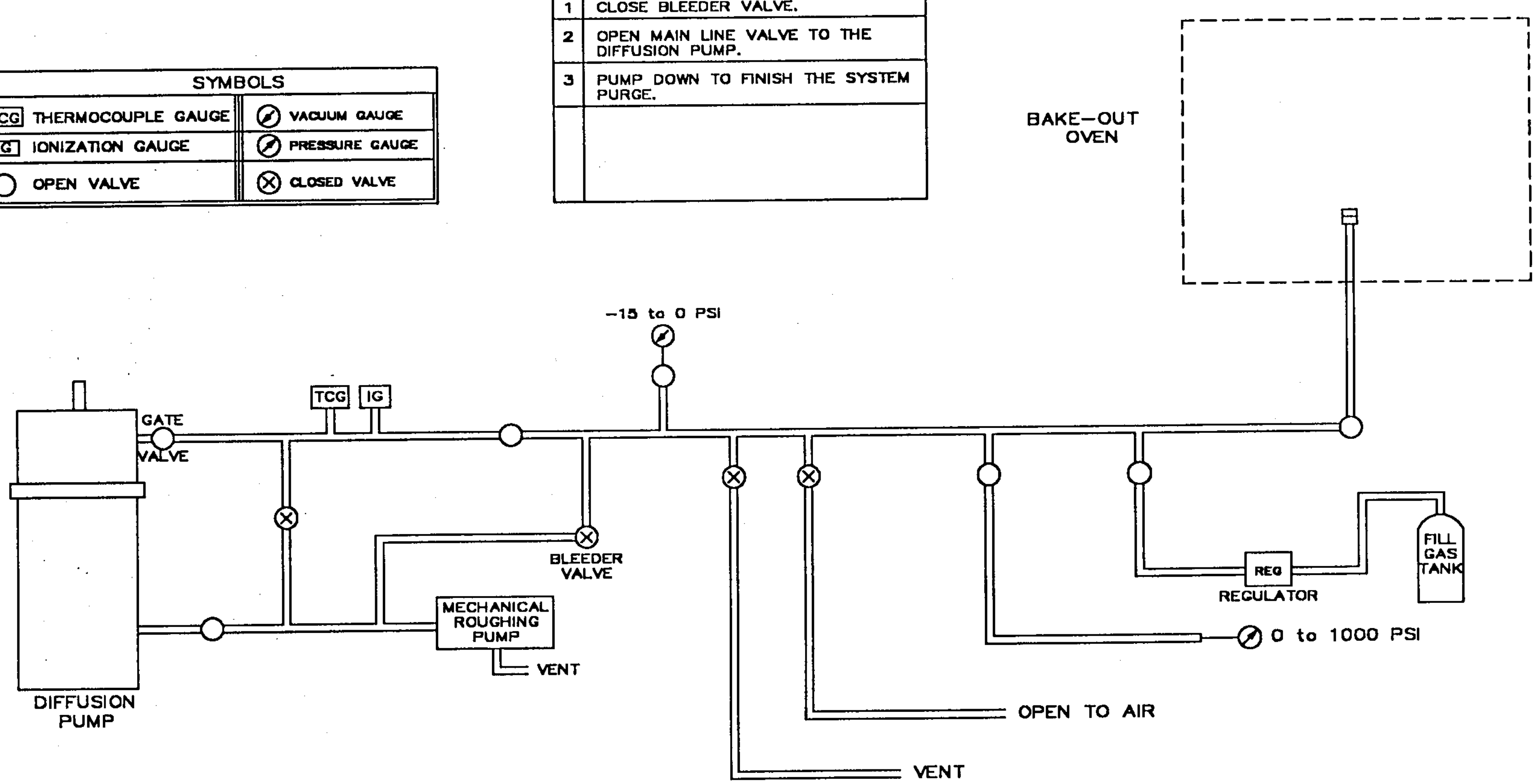
SYSTEM PURGE STEP 2

NOTES:

1	CLOSE BLEEDER VALVE.
2	OPEN MAIN LINE VALVE TO THE DIFFUSION PUMP.
3	PUMP DOWN TO FINISH THE SYSTEM PURGE.

SYMBOLS

TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

GAP PRESSURIZING SEQUENCE

SIZE | CAGECO 0Z887 | DRAWING NO. MDT610-13 | REV A

SCALE N/A | WEIGHT | SHEET 13 OF 14

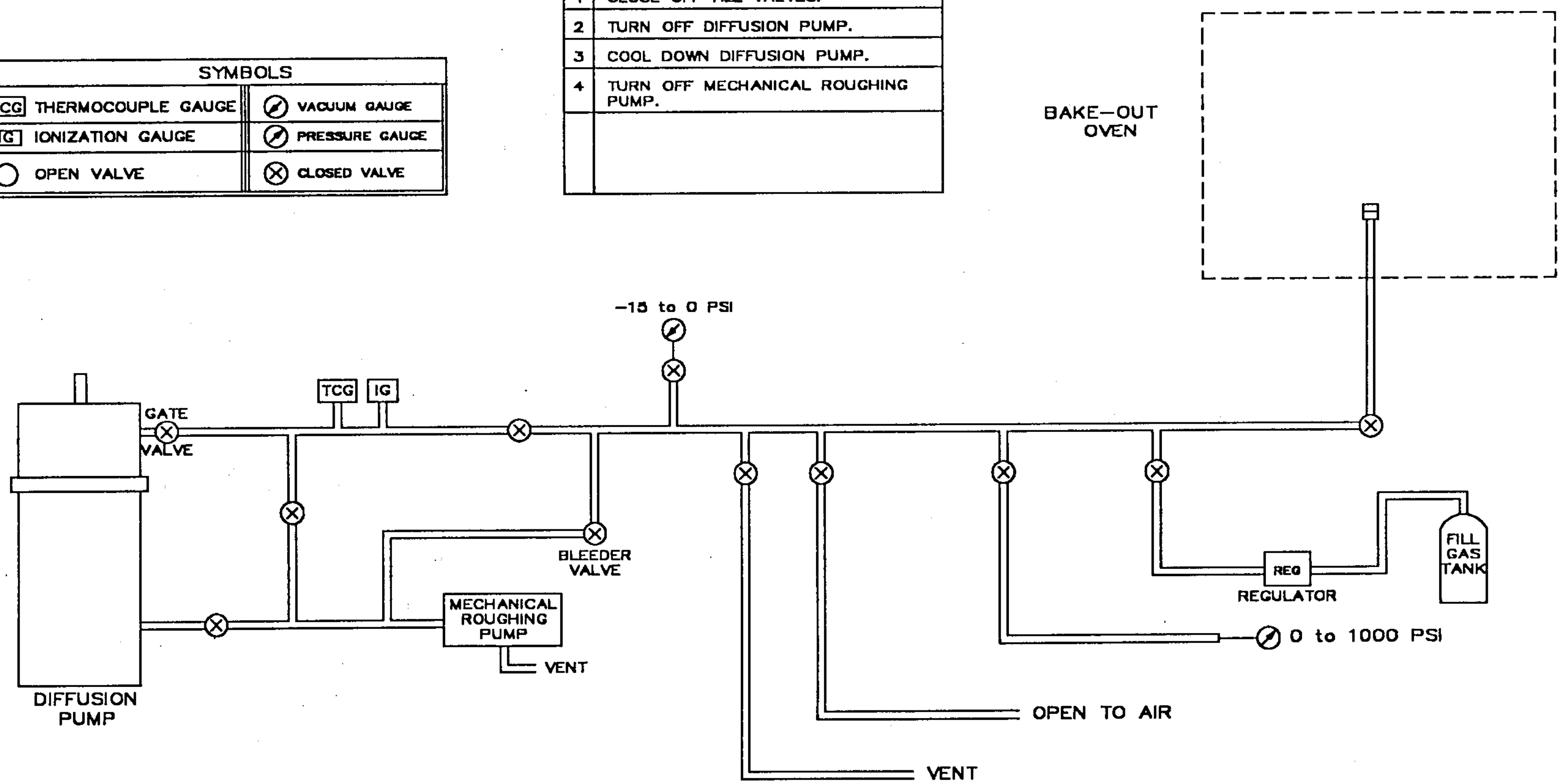
REVISIONS			
LTR	DESCRIPTION	DATE	APVD

SYSTEM SHUT DOWN

NOTES:

1	CLOSE OFF ALL VALVES.
2	TURN OFF DIFFUSION PUMP.
3	COOL DOWN DIFFUSION PUMP.
4	TURN OFF MECHANICAL ROUGHING PUMP.

SYMBOLS	
TCG THERMOCOUPLE GAUGE	VACUUM GAUGE
IG IONIZATION GAUGE	PRESSURE GAUGE
OPEN VALVE	CLOSED VALVE



REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	12-94
CHKR		
APPD		

CONTRACT/JOB NUMBER
N60921-94-C-A345

C. C. E.

GAP PRESSURIZING
SEQUENCE

SIZE	CAGE CD	DRAWING NO.	REV
	0Z887	MDT610-14	A
SCALE N/A		WEIGHT	SHEET 14 OF 14

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

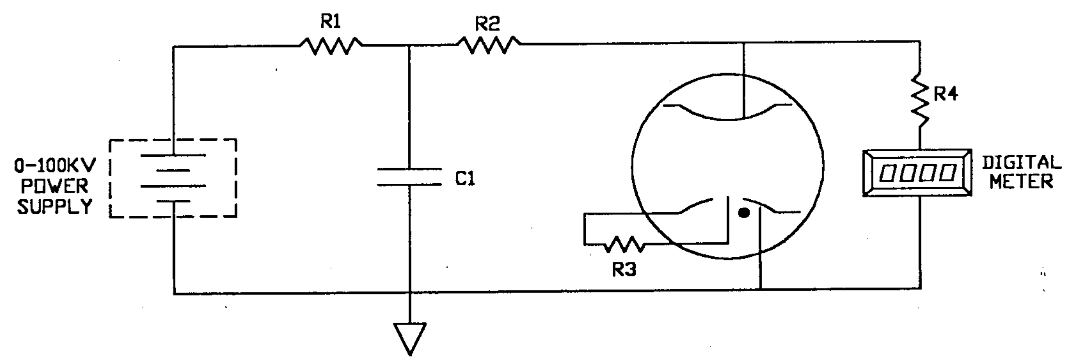
R1 = 200Meg OHMS (MAY BE 35Meg OHMS FOR E-E VOLTAGE LESS THAN 35KV)

R2 = 10 OHMS

R3 = 10K OHMS to 100K OHMS

R4 = 10^{10} OHMS

C1 = 0.001uf



REFERENCE ONLY		
PART NO. NEXT ASSY.		USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	11-94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

ELECTRICAL
PROCESSING
SCHEMATIC

SIZE	CAGECO 0Z887	DRAWING NO. MDT610-15	REV A
SCALE N/A		WEIGHT	SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APVD

R1 = 200Meg OHMS (MAY BE 35Meg OHMS FOR E-E VOLTAGE LESS THAN 35KV)

R2 = 10 OHMS

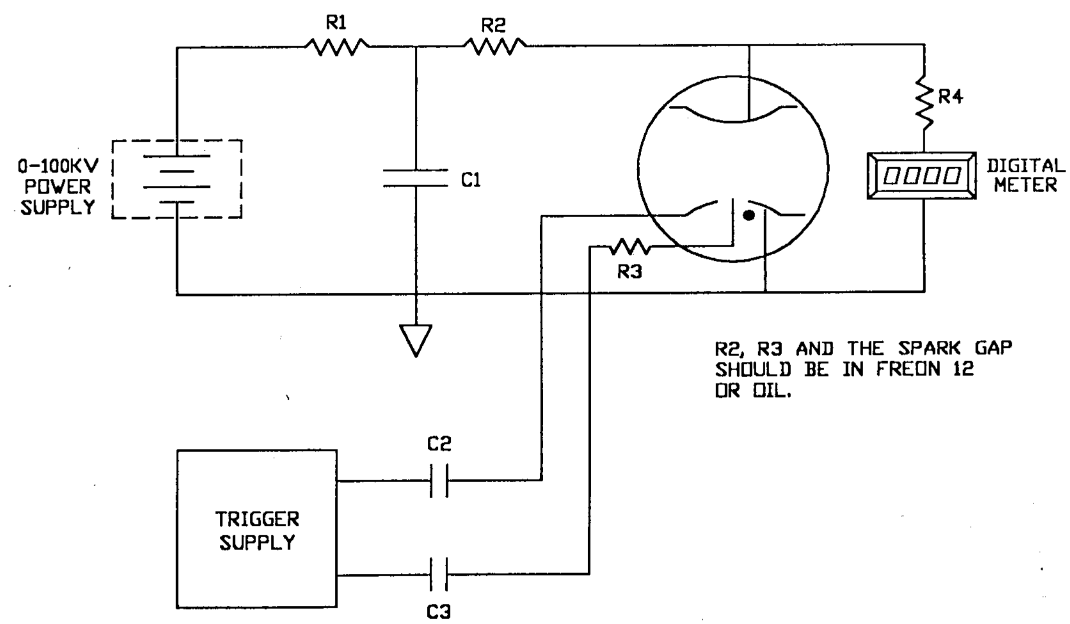
R3 = 10K OHMS to 100K OHMS

R4 = 10^{10} OHMS

C1 = 0.26uf

C2 = 1000pf

C3 = 1000pf

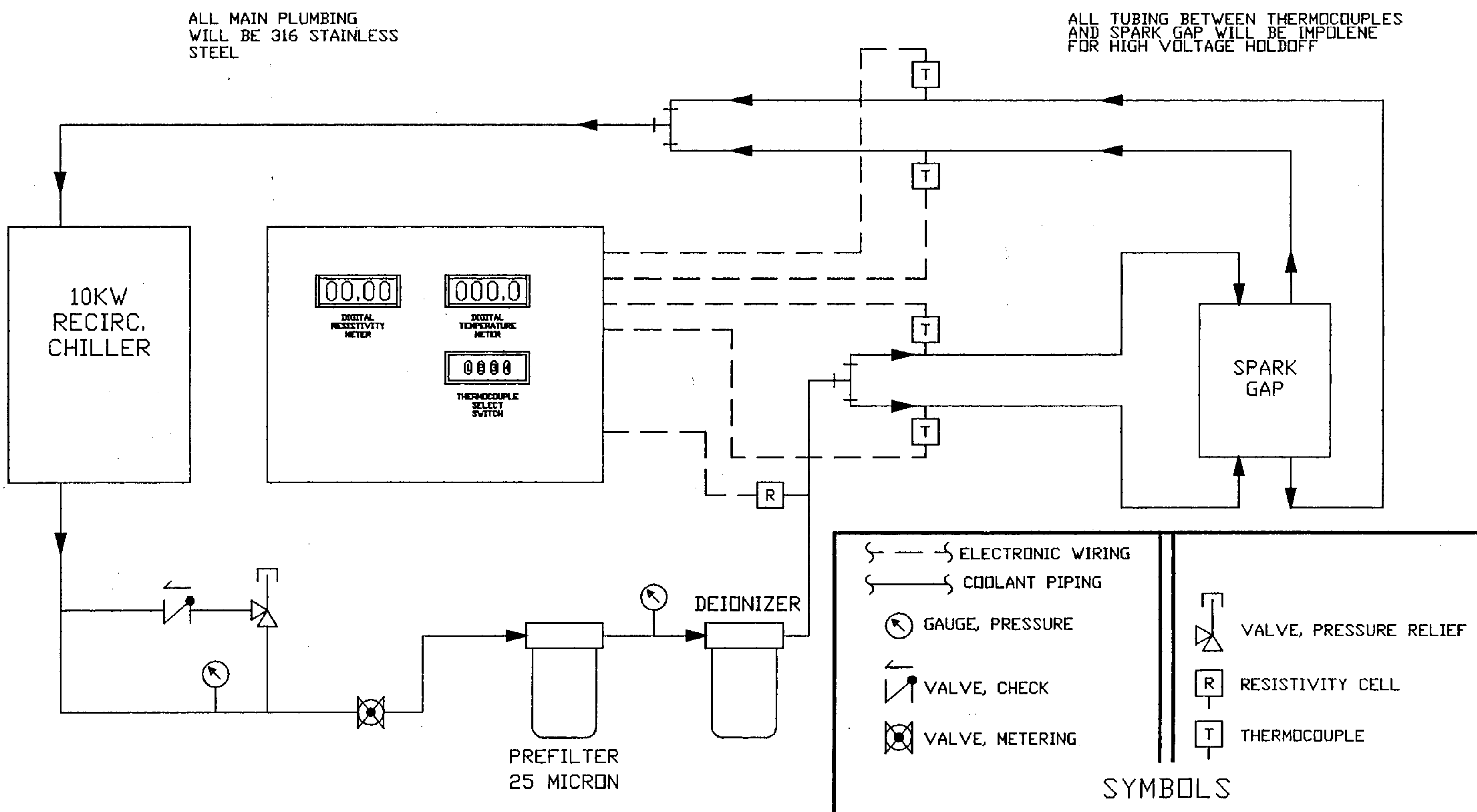


R2, R3 AND THE SPARK GAP SHOULD BE IN FREON 12 OR OIL.

REFERENCE ONLY			UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES		DATE	C. C. E.
			TOLERANCES OF FRACTIONS ±1/64	DRAWN B.W.W.	11-94	ELECTRICAL TESTING SCHEMATIC
			TOLERANCES OF DECIMALS	CHKR		
			.X ±0.01 / .XX ±0.005 / ∠±0.5°	APPD		
			1. BREAK EDGES 1/64 MAX 2. DO NOT SCALE THIS DRAWING 3. DIMENSION TO ANSI Y14.5 1982 4. MAX. ALL MACHINED SURFACES.			SIZE / CAGECD 0Z887 / DRAWING NO. MDT610-16 / REV A
PART NO.	NEXT ASSY.	USED ON		CONTRACT/JOB NUMBER N60921-94-C-A345		SCALE N/A / WEIGHT / SHEET 1 OF 1
APPLICATION						

COOLING SYSTEM

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 .XX ±0.005 ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

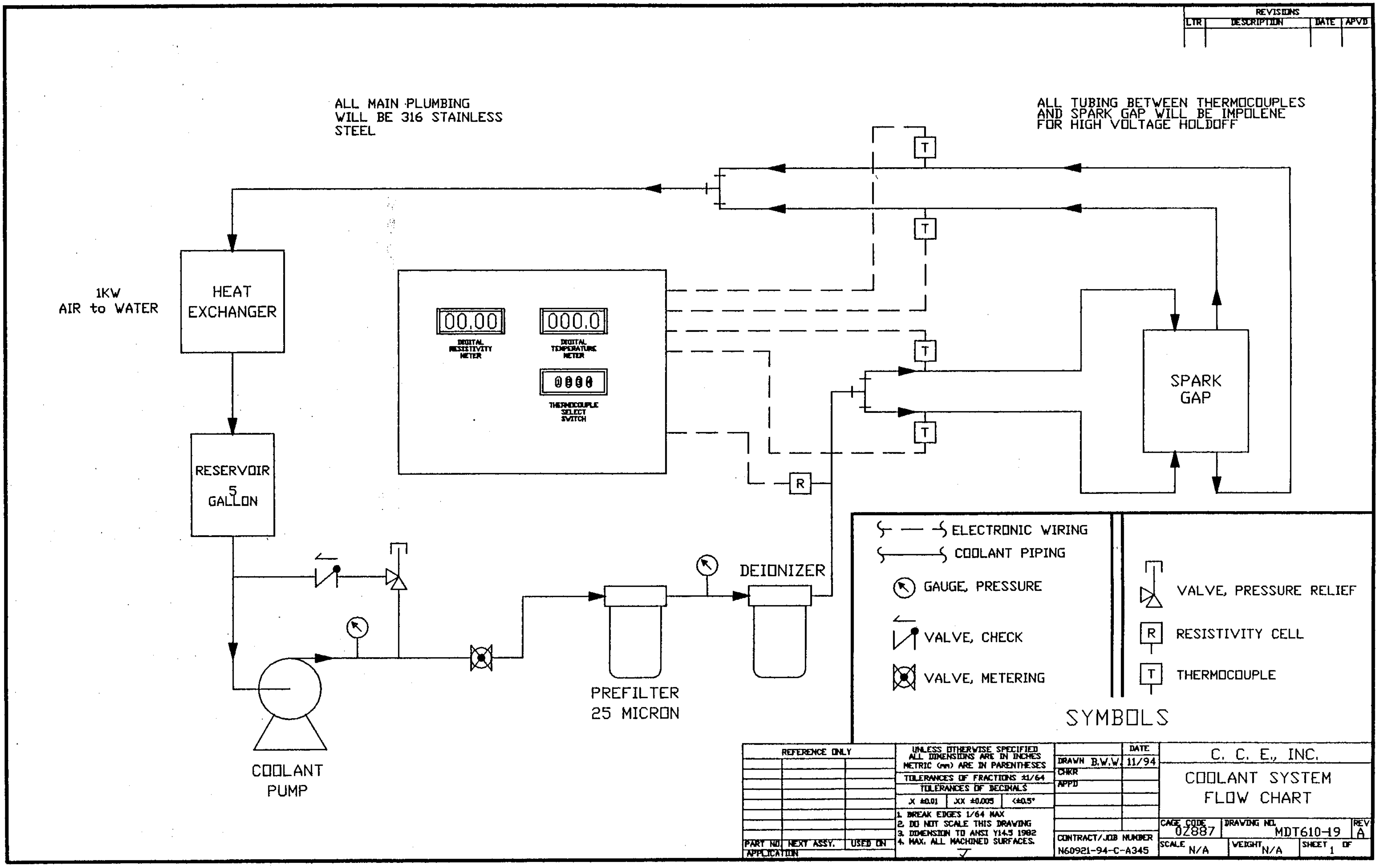
		DATE
DRAWN	B.W.W.	11/94
CHKR		
APPD		

CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E., INC.

COOLANT SYSTEM
FLOW CHART

CAGE CODE	DRAWING NO.	REV
0Z887	MDT610-20	A
SCALE N/A	WEIGHT N/A	SHEET 1 OF



REVISIONS
LTR
DESCRIPTION
DATE
APVD
ALL MAIN PLUMBING WILL BE 316 STAINLESS STEEL
ALL TUBING BETWEEN THERMOCOUPLES AND SPARK GAP WILL BE IMPOLENE FOR HIGH VOLTAGE HOLDOFF
1KW AIR to WATER
HEAT EXCHANGER
00.00
DIGITAL RESISTIVITY METER
000.0
DIGITAL TEMPERATURE METER
0000
THERMOCOUPLE SELECT SWITCH
T
T
T
T
R
SPARK GAP
RESERVOIR 5 GALLON
COOLANT PUMP
PREFILTER 25 MICRON
DEIONIZER
ELECTRONIC WIRING
COOLANT PIPING
GAUGE, PRESSURE
VALVE, CHECK
VALVE, METERING
VALVE, PRESSURE RELIEF
RESISTIVITY CELL
THERMOCOUPLE
SYMBOLS
REFERENCE ONLY
PART NO
NEXT ASSY.
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01
.XX ±0.005
∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.
DATE
DRAWN B.W.W. 11/94
CHKR
APPD
CONTRACT/JOB NUMBER
N60921-94-C-A345
C. C. E., INC.
COOLANT SYSTEM FLOW CHART
CAGE CODE 0Z887
DRAWING NO. MDT610-19
REV A
SCALE N/A
WEIGHT N/A
SHEET 1 OF

COOLING SYSTEM PARTS LIST

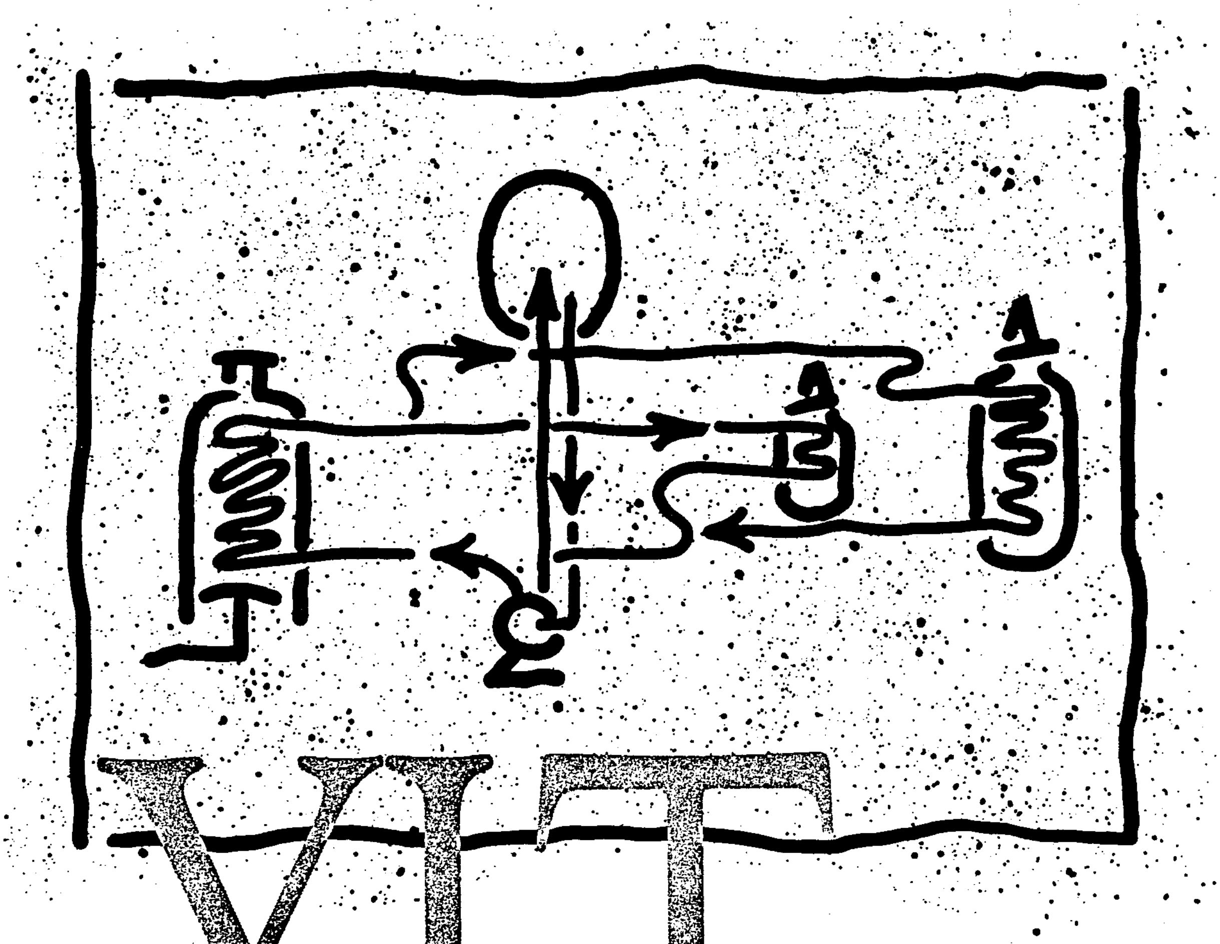
ITEM	DESCRIPTION	MANUFACTURER	QUANTITY	PRICE	EXTENDED 1	EXTENDED 2
1	COOLANT PUMP 5.5 GPM, 15ft HEAD PART # 815-BR113	MARCH	1	$239.00	$239.00	
2	HEAT EXCHANGER AIR TO WATER 1KW SERIES 6321	LYTRON	1	$453.00	$453.00	
	CFT SERIES CHILLER 10KW PART # CFT-300A	NESLAB	1	$4,885.00		$4,885.00
3	METERING VALVE PART # SS-4L	SWAGELOK	1	$66.00	$66.00	$66.00
4	FLOW SENSOR PART # DF-0708SS	KOBOLD	1	$512.00	$512.00	$512.00
5	RESISTIVITY MONITOR PART # H-05970-65	COLE-PARMER	1	$375.00	$375.00	$375.00
6	RESISTIVITY CELL 0-18Meg. PART # H-05970-70	COLE-PARMER	1	$165.00	$165.00	$165.00
7	PREFILTER HOUSING, 10in. PART # H-01508-70	COLE-PARMER	1	$68.00	$68.00	$68.00
	25 MICRON CARTRIDGE PART # H-29802-24		1	$23.85	$23.85	$23.85
8	DEIONIZING FILTER HOUSING 12 5/8IN. PART # H-01503-20	COLE-PARMER	1	$60.00	$60.00	$60.00
	RESIN CANISTOR PART# H-01503-30	COLE- PARMER	1	$29.70	$29.70	$29.70
9	5Gal. RESERVOIR TANK NALGENE w/SPIGOT PART# H-06321-11	COLE-PARMER	1	$50.50	$50.50	
10	DIAL GAUGE 0-160PSI PART # H-68006-06	COLE-PARMER	2	$44.20	$88.40	$88.40
11	"50" SERIES CHECK VALVE PART# SS-53S4	SWAGELOK	1	$60.00	$60.00	$60.00
12	"RL3" SERIES PRV PART# SS-RL3S4	SWAGELOK	1	$121.80	$121.80	$121.80
13	THERMOCOUPLE PIPE PLUG PROBE TYPE K, #H-08516-74	COLE-PARMER	4	$36.00	$144.00	$144.00
14	DIGITAL TEMP. METER with ALARM PART # H-92751-20	COLE-PARMER	1	$362.00	$362.00	$362.00
15	SWITCH BOX PART # H-92752-20	COLE-PARMER	1	$105.00	$105.00	$105.00

16	IMPOLENE TUBING 100ft SPOOL	CONSOLIDATED PLASTICS,INC	1	$50.00	$50.00	$50.00
17	REDUCER NIPPLE PART # SS-16-HRN-8	SWAGELOK CAJON	3	$23.50	$70.50	$70.50
18	FEMALE CONNECTOR PART # SS-810-7-4	SWAGELOK	4	$11.30	$45.20	$45.20
19	REDUCING ADAPTER PART # SS-12-RA-8	SWAGELOK CAJON	1	$17.80	$17.80	$17.80
20	UNION TEE PART # SS-400-3	SWAGELOK	4	$16.20	$64.80	$64.80
21	FEMALE BRANCH TEE PART # SS-400-3-4TTF	SWAGELOK	6	$23.30	$139.80	$139.80
22	3/4 IN. NPT FEMALE TEE PART # SS-12-T	SWAGELOK CAJON	1	$74.30	$74.30	$74.30
23	HEX REDUCING NIPPLE PART # SS-12-HRN-4	SWAGELOK CAJON	4	$13.10	$52.40	$52.40
24	1/4 IN. TUBE FEMALE CONNECTOR PART# SS-400-7-4	SWAGELOK	4	$8.20	$32.80	$32.80
25	1/4 IN. TUBE MALE CONNECTOR PART # SS-400-1-4	SWAGELOK	4	$5.10	$20.40	$20.40
				TOTAL	$3,491.25	$7,633.75

POLYDIMETHYLSILOXANE

DOW

SYLTHERM XLT
Heat Transfer Fluid



XLT

Product Technical Data

CONTENTS

†Trademark of Dow Corning Corporation

A Very Low Odor, Long-lasting Heat Transfer Fluid That's Ideal for Batch Processing

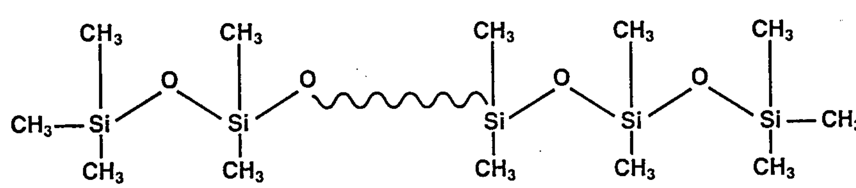
SYLTHERM XLT† heat transfer fluid is a specially formulated, high performance silicone polymer designed for use as a low temperature, liquid phase heat transfer medium. With a recommended use temperature range of -100°F to 500°F, SYLTHERM XLT fluid offers outstanding low temperature heat transfer and pumpability, plus excellent thermal stability. In addition, SYLTHERM XLT fluid has essentially no odor, is low in acute oral toxicity, and is not listed as reportable under SARA Title III, Section 313.[1] These features make SYLTHERM XLT fluid a viable alternative to many organic heat transfer fluids, chlorinated solvents, and CFCs that are presently used for low temperature, liquid phase service.

At -100°F, the viscosity of SYLTHERM XLT heat transfer fluid is only 12.6 centipoise. A low viscosity at low operating temperatures is a critical property because it allows high heat transfer coefficients with low pressure drops and pumping horsepower.

The -100°F to 500°F operating range of SYLTHERM XLT fluid makes it ideal for single fluid process heating and cooling applications (batch processing). Single fluid processing with SYLTHERM XLT fluid eliminates process interruption and the loss of temperature control associated with multiple fluid systems. Batch processing with SYLTHERM XLT fluid also eliminates system flush requirements associated with steam/brine and steam/glycol systems. SYLTHERM XLT fluid is noncorrosive toward metals and alloys commonly found in heat transfer systems.

In addition to the performance advantages of SYLTHERM XLT fluid, Dow's supporting services are unequaled. They include technical backup in the design phase, during operation, and after shutdown. Moreover, free analytical testing is provided to monitor fluid condition.

Figure 1—Dimethyl Polysiloxane Molecule



†Trademark of Dow Corning Corporation

[1]You may need to comply with similar or additional legislation in other countries. Contact your Dow representative for information.

Fluid Selection Criteria

When evaluating thermal fluids for specific applications, a variety of characteristics should be considered. Four of the most important are thermal stability, human health and environmental regulatory status, freeze point, and viscosity.

Stability

SYLTHERM XLT fluid offers excellent thermal stability at temperatures between -100°F and 500°F. The maximum recommended film temperature is 550°F.

Within its recommended use range, SYLTHERM XLT heat transfer fluid will not degrade to form solids or volatile compounds having substantially higher vapor pressures. As a result, system downtime for periodic fluid reprocessing and replacement is eliminated. SYLTHERM XLT fluid can tolerate occasional high-temperature upsets with only minimal change to the physical properties of the fluid. However, extended use at bulk temperatures above 500°F or film temperatures greater than 550°F, has the potential to generate higher system pressures and cause polymer cross-linking to occur. This will eventually cause the viscosity of the fluid to increase to a point where replacement will be required to restore system performance.

[1]*You may need to comply with similar or additional legislation in other countries. Contact your Dow representative for information.*

Low Odor, Non-reportable

SYLTHERM XLT fluid is virtually odorless and is low in acute oral toxicity. In addition, it is not listed as reportable under SARA Title III, Section 313.[1] SYLTHERM XLT fluid is well suited for use in pharmaceutical, fine chemical, and other processes where these properties are desired.

Freeze Point

SYLTHERM XLT fluid remains liquid below -100°F (freeze point is -168°F). This eliminates many of the problems associated with cold weather start-ups and shutdowns. Steam or electrical tracing, which is costly to install and operate, is not needed.

Viscosity

The excellent viscosity characteristics of SYLTHERM XLT fluid at low temperatures make it an efficient choice for very low temperature applications. The low viscosity of SYLTHERM XLT fluid at low temperatures (only 12.6 cps at -100°F) minimizes pressure drop and reduces pumping horsepower requirements. In addition, high heat transfer coefficients can be obtained over the fluid's entire temperature range. This can reduce refrigeration equipment energy consumption and cut process heat exchanger surface area requirements.

Thermal Stability

The thermal stability of a heat transfer fluid is dependent not only on its chemical structure but also on the design and operating temperature profile of the system in which it is used. Maximum fluid life can be obtained by following sound engineering practices in the design of the heat transfer system. Three key areas of focus are: designing and operating the heater and/or energy recovery unit, preventing chemical contamination, and eliminating contact of the fluid with air.

When units are operated at high temperatures, fluid velocity in fired heaters should be a minimum of 6 feet per second; a range of 6 to 12 feet per second should cover most cases. The actual velocity selected will depend on an economic balance between the cost of circulation and heat transfer surface. Operating limitations are usually placed on heat flux by equipment manufacturers. This heat flux is determined for a maximum film temperature by the operating conditions of the particular unit.

Heater Design and Operation

Poor design and/or operation of the fired heater can cause overheating, resulting in excessive thermal degradation of the fluid. Some problem areas to be avoided include:

1. Flame impingement.
2. Operating the heater above its rated capacity.
3. Modifying the fuel-to-air mixing procedure to change the flame height and pattern. This can yield higher flame and gas temperatures together with higher heat flux.
4. Low fluid velocity/high heat flux areas resulting in excessive heat transfer fluid film temperatures.

The manufacturer of the fired heater should be the primary contact in supplying you with the proper equipment for your heat transfer system needs.

Contamination Effects

SYLTHERM XLT heat transfer fluid is not sensitive to contamination by common piping contaminants, including water (during start-up and dry-out operations), rust, mill scale, lubricants, pipe dope, and small amounts of solvent and organic heat transfer fluid residue. SYLTHERM XLT fluid is somewhat more sensitive to contamination by acids or bases at elevated temperatures. As a result, lower molecular weight cyclic siloxanes can form and can raise the freeze point of the fluid. Similarly, contamination by water, oxygen, or other oxidants when the fluid is at an elevated temperature can result in cross-linking of polymer molecules and, if not corrected, can cause a gradual increase in viscosity. In order to minimize the likelihood of oxygen contamination, the system expansion tank should have an inert gas (such as nitrogen) blanket.

Expansion Tank

Figure 2 (page 6) is a simplified schematic of a recommended system loop design for SYLTHERM XLT heat transfer fluid. The expansion tank is positioned at the highest point in the system and has the capability for full flow of the heat transfer fluid through the tank. This design allows the expansion tank to be the lowest pressure point in the system, and the constant flow of heat transfer fluid through the tank ensures that vapors form only in the expansion tank. Once the system is heated up to the appropriate temperature and operating normally, system pressure will slowly increase until either the pressure in the expansion tank reaches the setting on the back pressure regulator valve, or the system reaches the vapor pressure for the temperature of the fluid in the expansion tank. When the back pressure regulator is set at a pressure lower than the equilibrium vapor pressure of the fluid for a given temperature, periodic venting of the volatile materials will take place. The fluid will suffer no deleterious effect; however, periodic additions of fluid will be needed to maintain system volume.

An inert gas (such as nitrogen) blanket on the expansion tank is required to prevent the fluid from coming into contact with the outside air. Without this inert gas blanket, humid, outside air is likely to be drawn into the tank whenever the system cools below its normal operating temperature. This moisture contamination can result in increased pressure in the system due to steam formation on the next heat-up cycle or form ice in refrigeration equipment during low temperature operation. To avoid this, the inert gas supply regulator should be adjusted and maintained at a low setting (3–5 psig). This will minimize both the inert gas consumption and the additive effects of the blanket gas on total system pressure.

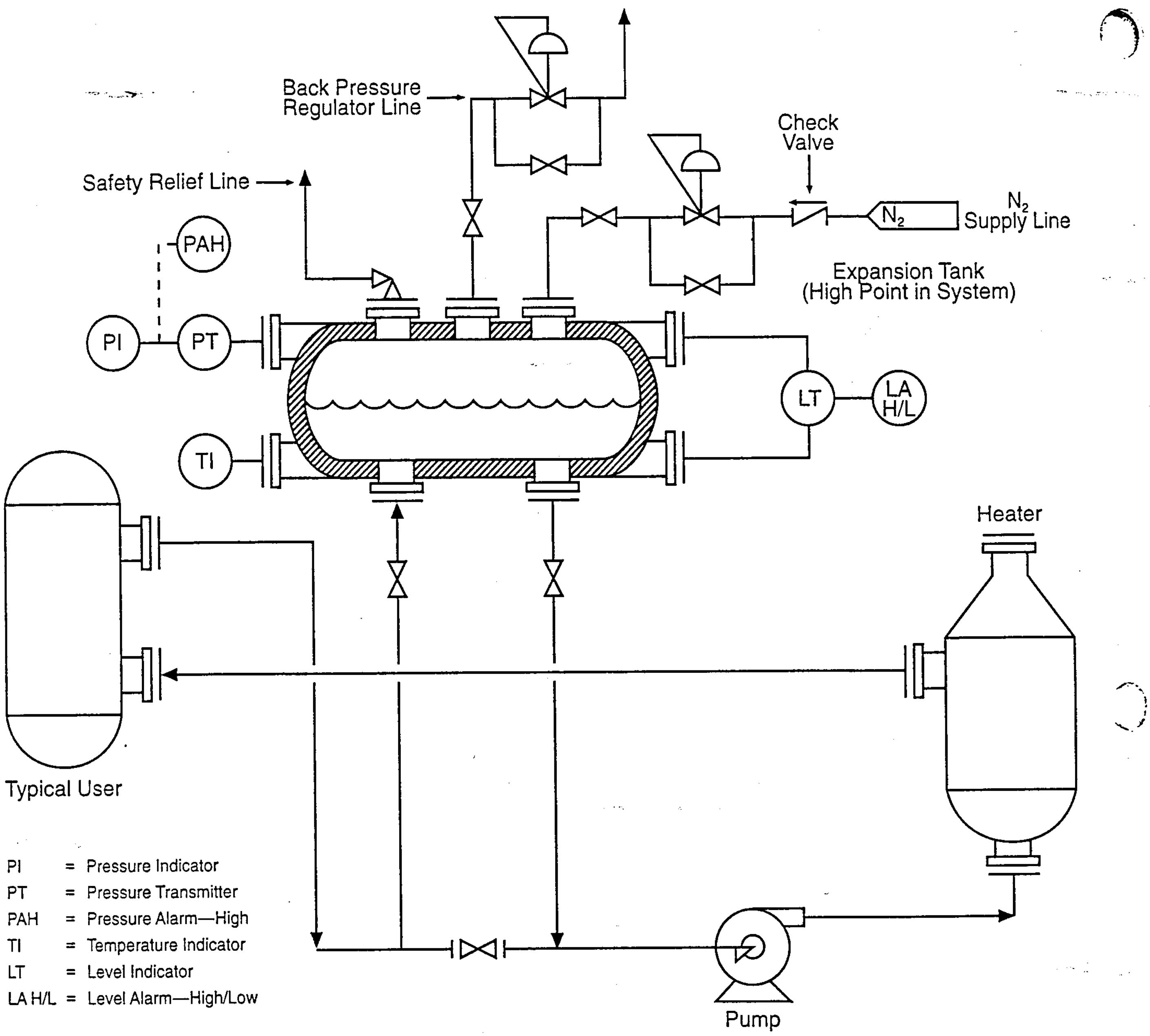
To prevent pump cavitation, the fluid pressure at the entrance to the pump must be above its vapor pressure, and there must be sufficient head in addition to the vapor pressure to satisfy the Net Positive Suction Head (NPSH) requirements of the pump. If the expansion tank is designed as shown in Figure 2, the back pressure regulator setting on the expansion tank will control the pressure at the entrance to the pump. The regulator set point should be 10 to 15 psi above the vapor pressure corresponding to the fluid temperature in the expansion tank.

NPSH requirements are primarily satisfied by the elevation of the expansion tank. The elevation is determined by calculating the total head necessary to overcome frictional line losses and specific NPSH requirements of the pump. In systems where such tank elevation is not practical, NPSH requirements can be met by increasing the amount of the blanket gas (usually nitrogen) in the vapor space of the expansion tank, thereby increasing the overall pressure in the tank. However, the additional system pressure created by the nitrogen should be accounted for during the system design.

The expansion tank design must satisfy two necessary requirements for proper start-up and operation of the system. First, the system piping to the expansion tank should be designed to permit full flow of fluid through the tank. A double drop leg design (see Figure 2) is the most effective arrangement to remove air, water vapors, and other noncondensibles during system start-up. For ongoing operation, flow of fluid through the tank can often be reduced as long as sufficient flow is maintained to prevent pump cavitation. The tank and connecting piping should also be insulated to prevent the condensation of any vapors that may accumulate in this portion of the system.

Second, the inert gas blanket on the expansion tank should allow for a continuous flow of inert gas to be purged through the vapor space during the initial start-up. Separate inert gas supply and discharge nozzles, spaced as far apart as possible, will help ensure that any volatile contaminants (such as water or solvents) will be swept from the system during initial start-up.

Figure 2—Simplified System Schematic for SYLTHERM XLT Heat Transfer Fluid



The vent lines from the safety relief valve and back pressure regulator should be discharged to a safe area away from open flame and other potential sources of ignition. An appropriate outside container located well away from building air-intake fans is recommended. The vented volatile materials will be typically classified as flammable.

The expansion tank should be sized so that it is approximately ¼ full when the system is at ambient temperature, and ¾ full when the system is at its maximum operating temperature. Expansion tank instrumentation and fittings must meet the design requirements of the anticipated operating temperatures and pressures of the system and should include (refer to Figure 2):

1. Electronic level gauge covering the full fluid level range.
2. Fluid temperature indicator.
3. Level alarm (high/low) with low level shutdown to protect pump.
4. Pressure indicator with high pressure alarm.

Corrosivity

SYLTHERM XLT heat transfer fluid is noncorrosive toward common metals and alloys used in heat transfer systems, as long as it remains uncontaminated. Even at the high temperatures involved, equipment usually exhibits excellent service life.

Carbon steel is used predominantly in heat transfer systems utilizing SYLTHERM XLT fluid, although low alloy steels, stainless steels, monel alloys, etc., are also used in miscellaneous pieces of equipment and instruments.

Most corrosion problems are caused by chemicals introduced into the system during cleaning or from process leaks. The severity and nature of the corrosivity will depend upon the amounts and type of contamination involved.

When special materials of construction are used, extra precaution should be taken to avoid contaminating materials containing the following:

Construction Material	*Contaminant*
Austenitic Stainless Steel	*Chlorides*
Nickel	*Sulfur*
Copper Alloys	*Ammonia*

Flammability and Fire Hazards

SYLTHERM XLT heat transfer fluid is a combustible material with a flash point of 116°F, a fire point of 140°F (C.O.C.), and an autoignition temperature of 662°F (ASTM Method D-2155).

Vapor leaks to the atmosphere are sometimes encountered. Such leaks, however small, should not be tolerated because of the cost of replacing lost medium. Experience has shown that leaking vapors have usually cooled well below the fire point, and fire has rarely resulted.

Leaks from flanges or valves into insulation are also potentially hazardous because they can lead to fires in the insulation. It has been found, for example, that leakage of organic materials into some types of insulation at elevated temperatures may result in spontaneous ignition due to auto-oxidation.

Vapors of SYLTHERM XLT fluid do not pose a serious flammability hazard at room temperature because the saturation concentration is so far below the lower flammability limit that ignition is extremely unlikely. Flammable mists are, however, possible under unusual circumstances where the time of exposure to an ignition source, the temperature of the source and the atmosphere, the volume of mixture, the fuel-air ratio, and the mist particle size all fall within a somewhat narrow range.

Static Spark Hazard

Heat transfer fluids like SYLTHERM XLT heat transfer fluid are generally poor electrical conductors, which means they can build up static charges and discharge static electricity within vessels or while being drained out of vessels. Therefore, safe engineering practice dictates that oxygen must be excluded from the headspace of the expansion tank. Similar precautions concerning static sparks should be taken when loading and unloading used fluid and volatiles.

Flammable-gas Detectors

Silicone vapors can deactivate many brands of flammable-gas detectors. However, several manufacturers offer detectors for silicone environments and report the operating life of these detectors is not affected by the presence of silicone materials. Contact your Dow Technical Service representative at 1-800-447-4369 for listings of suppliers of these detectors.

New System Start-up

The following information is a brief summary of the general recommendations and procedures for starting up a system with SYLTHERM XLT heat transfer fluid.

Prior to start-up, the system must be cleaned of dirt, welding slag, and other miscellaneous debris. Extra care taken to keep the system clean during construction can eliminate extensive cleaning prior to start-up. As mentioned previously, it is also very important to remove any residual water from the system prior to the installation of SYLTHERM XLT heat transfer fluid.

Because the design of all heat transfer systems differs to some extent, a detailed set of start-up procedures covering all possible systems is not practical. Users should develop procedures based on their own internal standards and recommendations from heat transfer equipment suppliers. The following procedures are presented as general guidelines only.

1. If the system is flushed with water or a suitable solvent, be sure that the fluid is circulated sufficiently through the system to pick up any remaining oils and debris. The pump and suction strainer should be checked periodically during this time to ensure that any collected debris is not severely restricting fluid flow to the pump inlet. If a filter is installed, filter the fluid for as long as practical through a 10-micron filter.
2. Completely drain the flush fluid by pressurizing the system with nitrogen or dry air, and opening all low-point drains. Alternately open and close all drain valves to increase the velocity of the gas flow. This will help to remove residual water/solvent and loose foreign particles.
3. Fill the system with SYLTHERM XLT heat transfer fluid. Circulate the fluid cold. Check for and repair any leaks. If a flush fluid was not used, check the pump suction strainers for any collected solids. If a filter is installed, continue circulating the fluid through the filter until the upper temperature limit of the filter is approached.
4. For the initial stages of start-up, the inert gas blanket system on the expansion tank should be arranged to allow a steady purge (1–2 scfm) of gas to sweep through the vapor space of the tank. At the same time, the valves controlling fluid flow should be set so that the maximum amount of fluid flows through the expansion tank.
5. Increase the fluid temperature to 250°F as measured at the heater outlet. The rate of increase should be held to 100°F per hour or the maximum recommended for the various pieces of equipment in the system, whichever is lower. This will allow the equipment to be brought up to temperature safely and enable start-up personnel to check for leaks and ensure that all instrumentation is operating properly. Maintain the 250°F temperature until the amount of steam or solvent vapors exiting the vent line from the expansion tank has subsided. This may require several hours.
6. Raise the fluid temperature to 300°F and repeat the procedure described previously until venting has again subsided. Repeat the procedure once more at 350°F.

   It is essential that sufficient flow of fluid be maintained through the expansion tank during these steps so that the temperature in the tank is high enough to boil out any residual moisture or solvents from the system.
7. Set the nitrogen supply regulator in the range of 3 to 5 psig. Engage the back pressure regulator at the specified design pressure. No further venting will occur unless the pressure in the expansion tank exceeds the specified pressure. Any further pressure increase in the tank should only result from compression of the inert gas by the expanding fluid or from the generation of volatile materials by SYLTHERM XLT heat transfer fluid. Any additional inert gas should enter the tank only when the tank pressure falls below the 3 to 5 psig setting (e.g., as it would if the system were to be shut down).

   For systems which operate primarily at low temperatures, and do not have the capability of heating the fluid to the temperatures outlined above, other methods of water removal may be required. The use of molecular sieves or ion exchange resins to remove the water from the fluid may be necessary.

Health and Safety Considerations

A Material Safety Data Sheet (MSDS) for SYLTHERM XLT heat transfer fluid is available by contacting your nearest Dow sales representative, or by calling 1-800-447-4369. The MSDS contains complete health and safety information regarding the use of this product. Read and understand the MSDS before handling or otherwise using this product.

SYLTHERM XLT heat transfer fluid has been studied for acute toxicological properties under the Federal Hazardous Substance Act guidelines. As a result of the FHSA study, SYLTHERM XLT heat transfer fluid has been classified as:

- Nontoxic, with regard to acute oral ingestion or dermal absorption to quantities typically contacted during normal use
- Having minimal potential for eye or skin irritation

Additionally, studies indicate that repeated, prolonged skin contact should not result in irritation. Normal industrial handling procedures are adequate to handle this product.

Unlike many low temperature heat transfer fluids, SYLTHERM XLT fluid has minimal odor and no airborne exposure limits. However, vapors of SYLTHERM XLT heat transfer fluid released into the air at temperatures above 300°F (149°C) may cause some temporary eye and/or respiratory irritation due to the partial oxidation of the fluid. In areas with adequate ventilation, no special breathing apparatus is required. Prolonged exposures or exposures in poorly ventilated areas with high vapor concentrations should be avoided. The predominant by-products in these vapors are low-molecular-weight dimethylsiloxanes. These cyclic and linear siloxanes are commonly used in such personal care products as cosmetics and deodorants.

Leaks or spills of SYLTHERM XLT heat transfer fluid into soil typically result in the gradual break down of the polymer to form naturally occurring materials like silica, water, and carbon dioxide.

Customer Service for Users of SYLTHERM XLT Heat Transfer Fluid

Fluid Analysis

The Dow Chemical Company offers an analytical service for SYLTHERM XLT heat transfer fluid. It is recommended that users send a one-pint representative sample at least annually to:

Testing Section for DOWTHERM and SYLTHERM Fluids
The Dow Chemical Company
Larkin Laboratory/2040 Receiving
Midland, Michigan 48674

This analysis gives a profile of fluid changes to help ensure against trouble from product contamination.

When a sample is taken from a hot system it should be cooled to below 100°F before it is put into the shipping container. Cooling the sample below 100°F will prevent the possibility of thermal burns to personnel; also, the fluid is then below its flash point. In addition, any low boilers will not flash and be lost from the sample. Cooling can be done by either a batch or continuous process. The batch method consists of isolating the hot sample of fluid from the system in a properly designed sample collector and then cooling it to below 100°F. After it is cooled, it can be withdrawn from the sampling collector into a container for shipment.

The continuous method consists of controlling the fluid at a very low rate through a steel or stainless steel cooling coil so as to maintain it at 100°F or lower as it comes out of the end of the cooler into the sample collector. Before a sample is taken, the sampler should be thoroughly flushed. This initial fluid should be returned to the system or disposed of in a safe manner.

It is important that samples sent for analysis be representative of the charge in the unit. Ordinarily, samples should be taken from the main circulating line of a fluid system. Occasionally, additional samples may have to be taken from other parts of the system where specific problems exist.

Retrofill

SYLTHERM XLT heat transfer fluid has successfully replaced organic fluids in existing heat transfer systems. However, there are engineering considerations that should be addressed due to the unique characteristics of SYLTHERM XLT heat transfer fluid. It is suggested that The Dow Chemical Company be consulted in advance of fluid purchase and installation to discuss how best to optimize fluid performance in your system.

Table 1—Physical Properties of SYLTHERM XLT Heat Transfer Fluid[1]

Appearance	Crystal Clear Liquid
Viscosity at 77°F (25°C), cps	1.4
Flash Point[2], Closed Cup, Typical	116°F (47°C)
Flash Point[3], Open Cup, Typical	130°F (54°C)
Autoignition Point, ASTM D-2155	662°F (350°C)
Acid Number, Typical	0.01
Freeze Point	-168°F (-111°C)
Density at 77°F (25°C), lb/gal	7.1
Specific Gravity at 77°F (25°C)	0.85
Heat of Combustion, Btu/lb	14,100
Average Molecular Weight	317
Pseudo Critical Constants, T_c	620°F (327°C)
P_c, atm	12

[1]*Not to be construed as specifications.*
[2]*ASTM D92*
[3]*ASTM D93*

Storage and Shelf-life

Dow Corning Corporation certifies that SYLTHERM XLT heat transfer fluid, when stored in its original container, will meet sales specification requirements for a period of 24 months from date of shipment.

Store fluid at ambient temperature.

NOTE: *If outside storage of drums is planned, it is suggested that some type of removable drum cover be used to prevent water from entering the drum through the bung seal.*

Packaging

SYLTHERM XLT heat transfer fluid is routinely supplied in 35-lb (16-kg), 375-lb (170-kg) containers (net weight) and in bulk quantities.

Table 2—Saturation Properties of SYLTHERM XLT Fluid (English Units)

Temp. °F	Density lb/ft³	Specific Heat Btu/(lb)(°F)	Therm. Cond. Btu/(hr)(ft²)°F/ft)	Viscosity cps	Vap. Press. psia
-100	57.76	0.337	0.0748	12.6	0.0
-80	57.17	0.344	0.0736	8.8	0.0
-60	56.58	0.351	0.0724	6.4	0.0
-40	55.99	0.357	0.0711	4.8	0.0
-20	55.39	0.364	0.0699	3.7	0.0
0	54.80	0.371	0.0686	2.9	0.0
20	54.20	0.378	0.0673	2.3	0.0
40	53.60	0.385	0.0659	1.9	0.0
60	52.99	0.391	0.0646	1.6	0.0
80	52.37	0.398	0.0632	1.3	0.0
100	51.75	0.405	0.0618	1.1	0.1
120	51.11	0.412	0.0603	1.0	0.1
140	50.46	0.419	0.0589	0.86	0.2
160	49.80	0.426	0.0574	0.75	0.4
180	49.12	0.432	0.0559	0.67	0.7
200	48.43	0.439	0.0544	0.60	1.2
220	47.72	0.446	0.0528	0.54	1.8
240	46.99	0.453	0.0513	0.49	2.7
260	46.24	0.460	0.0497	0.44	3.9
280	45.47	0.466	0.0481	0.40	5.5
300	44.68	0.473	0.0465	0.37	7.5
320	43.86	0.480	0.0449	0.34	10.2
340	43.02	0.487	0.0432	0.32	13.5
360	42.15	0.494	0.0416	0.29	17.5
380	41.25	0.500	0.0399	0.28	22.4
400	40.32	0.507	0.0382	0.26	28.3
420	39.37	0.514	0.0365	0.24	35.3
440	38.38	0.521	0.0348	0.23	43.4
460	37.35	0.528	0.0330	0.22	52.8
480	36.29	0.535	0.0313	0.20	63.6
500	35.20	0.541	0.0295	0.19	75.9
520	34.06	0.548	0.0277	0.18	89.8
540	32.89	0.555	0.0259	0.17	105.3

Table 3—Saturation Properties of SYLTHERM XLT Fluid (SI Units)

Temp. °C	Density kg/m³	Specific Heat kJ/(kg)(K)	Therm. Cond. W/(m)(K)	Viscosity (mPa)(s)	Vap. Press. kPa
-73	923.91	1.411	0.1294	12.44	0.0
-70	921.35	1.418	0.1288	11.26	0.0
-60	912.81	1.444	0.1269	8.25	0.0
-50	904.30	1.470	0.1251	6.21	0.0
-40	895.78	1.495	0.1231	4.80	0.0
-30	887.26	1.521	0.1212	3.79	0.0
-20	878.71	1.547	0.1192	3.04	0.0
-10	870.11	1.572	0.1171	2.49	0.0
0	861.45	1.598	0.1150	2.07	0.0
10	852.72	1.624	0.1129	1.74	0.0
20	843.89	1.649	0.1108	1.48	0.0
30	834.96	1.675	0.1086	1.27	0.3
40	825.90	1.701	0.1064	1.11	0.6
50	816.71	1.726	0.1042	0.97	1.1
60	807.36	1.752	0.1019	0.86	1.8
70	797.83	1.777	0.0996	0.76	3.0
80	788.12	1.803	0.0973	0.68	4.7
90	778.21	1.829	0.0949	0.62	7.2
100	768.08	1.854	0.0925	0.56	10.6
110	757.71	1.880	0.0901	0.51	15.3
120	747.09	1.906	0.0877	0.47	21.5
130	736.20	1.931	0.0852	0.43	29.7
140	725.03	1.957	0.0827	0.40	40.1
150	713.56	1.983	0.0802	0.37	53.2
160	701.78	2.008	0.0777	0.34	74.6
170	689.67	2.034	0.0751	0.32	89.4
180	677.21	2.060	0.0725	0.30	113.5
190	664.39	2.085	0.0699	0.28	142.2
200	651.19	2.111	0.0673	0.26	176.2
210	637.59	2.137	0.0646	0.25	215.9
220	623.59	2.162	0.0620	0.24	261.9
230	609.16	2.188	0.0593	0.22	314.8
240	594.28	2.214	0.0566	0.21	375.1
250	578.95	2.239	0.0538	0.20	443.5
260	563.15	2.265	0.0511	0.19	520.3
270	546.85	2.291	0.0483	0.18	606.3
280	530.05	2.316	0.0455	0.18	701.8
290	512.73	2.342	0.0427	0.17	807.5

Figure 3—Thermal Conductivity of SYLTHERM XLT Fluid

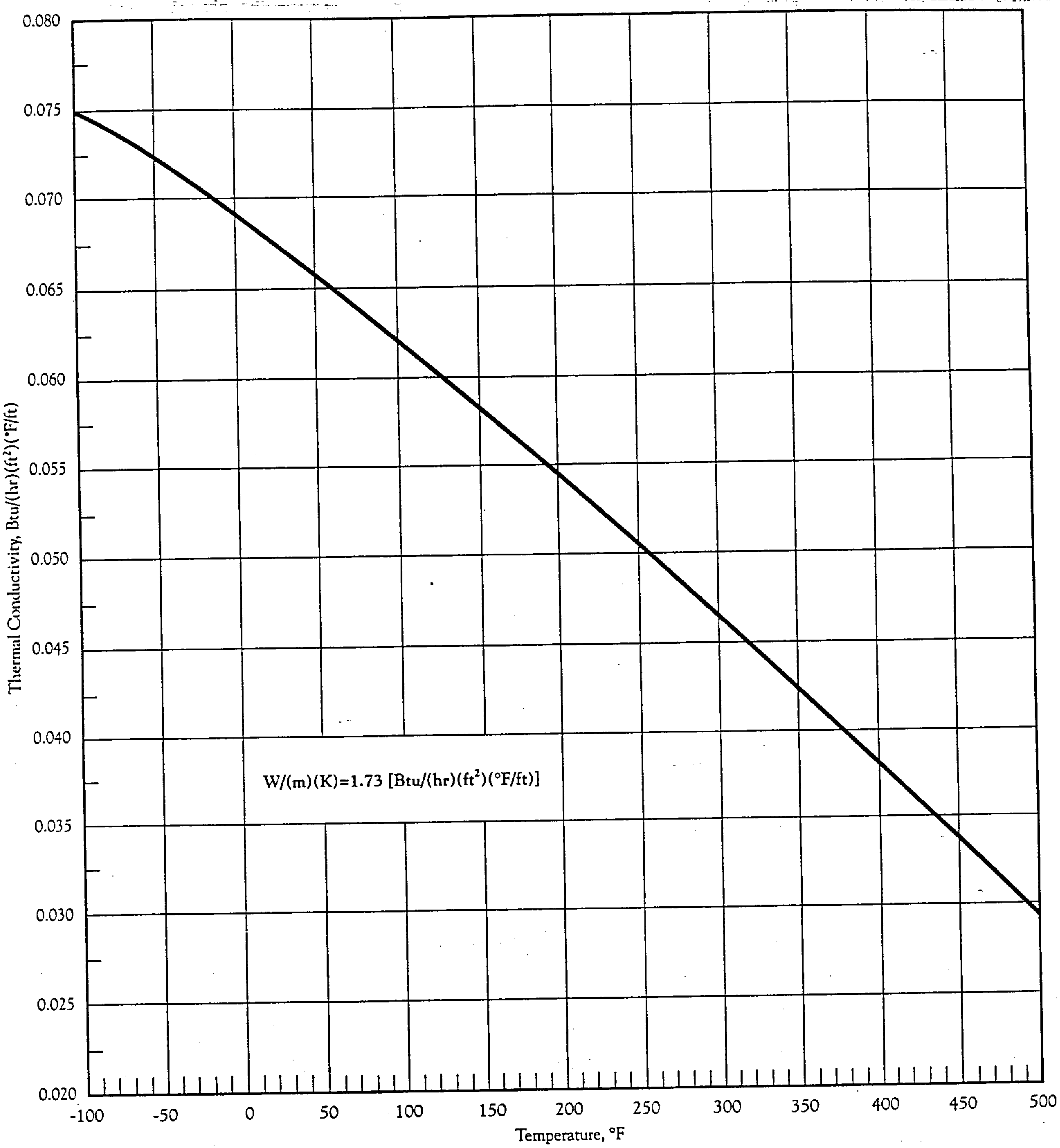


Figure 4—Vapor Pressure of SYLTHERM XLT Fluid

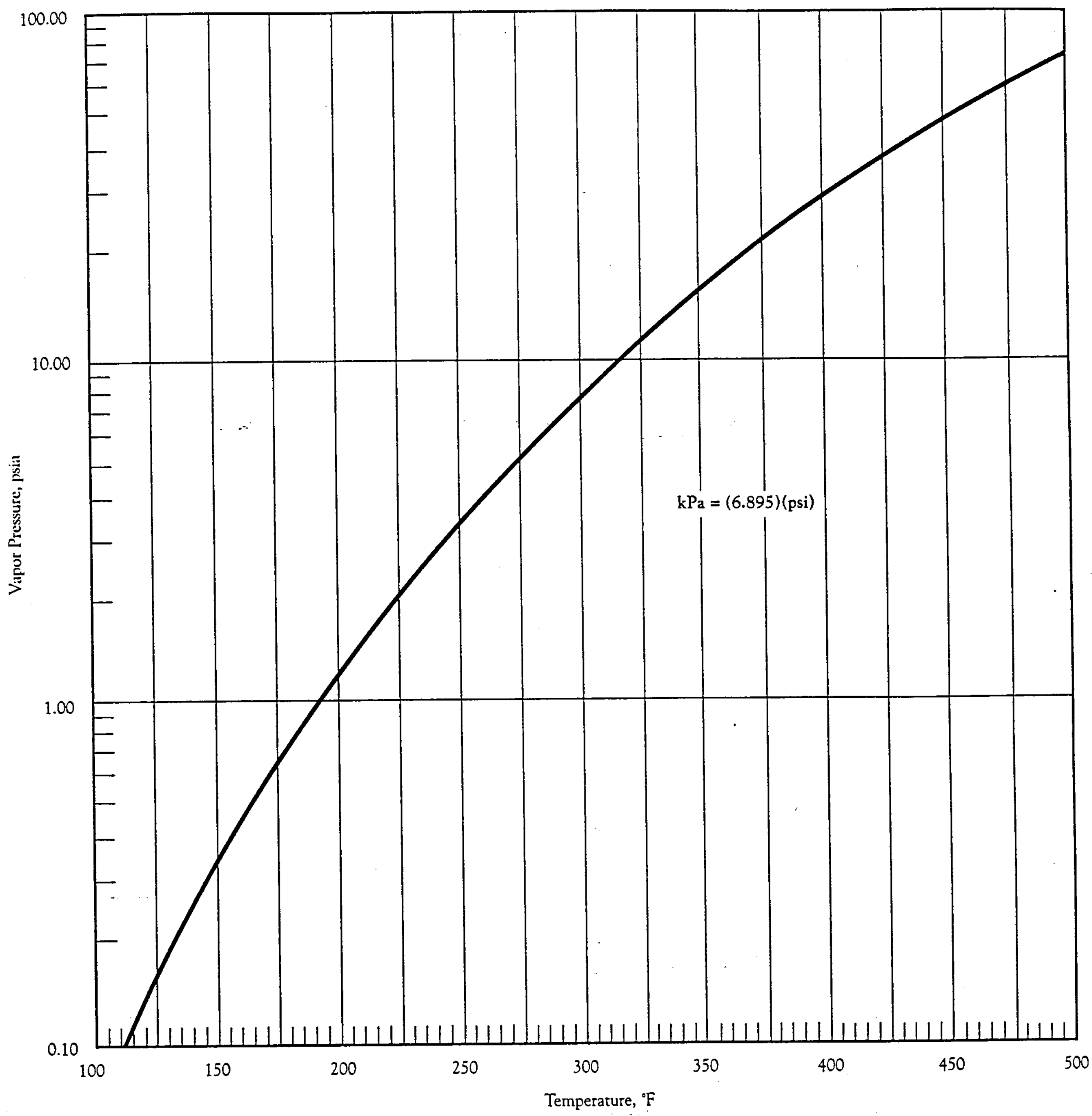


Figure 5—Absolute Viscosity of SYLTHERM XLT Fluid

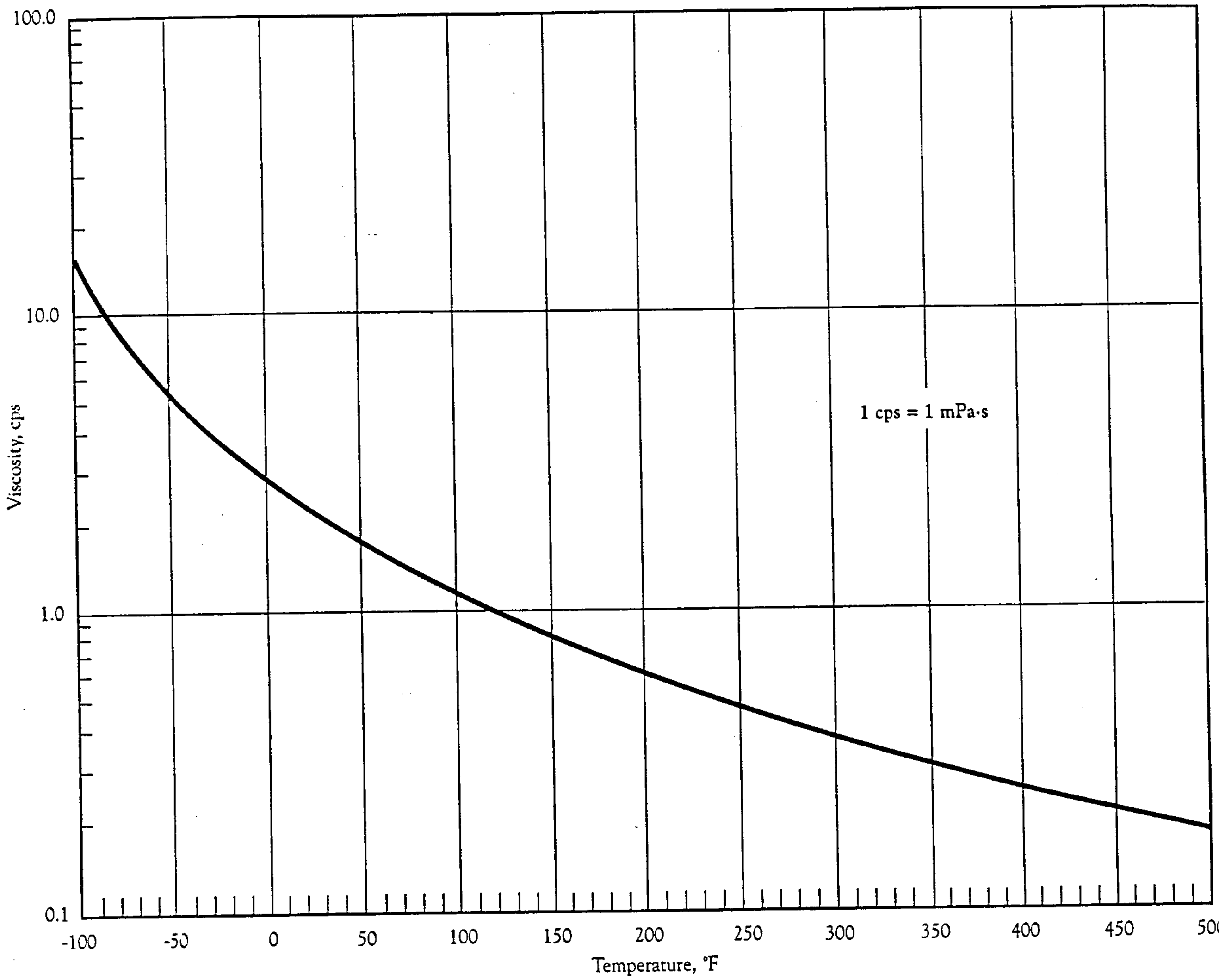


Figure 6—Density of SYLTHERM XLT Fluid

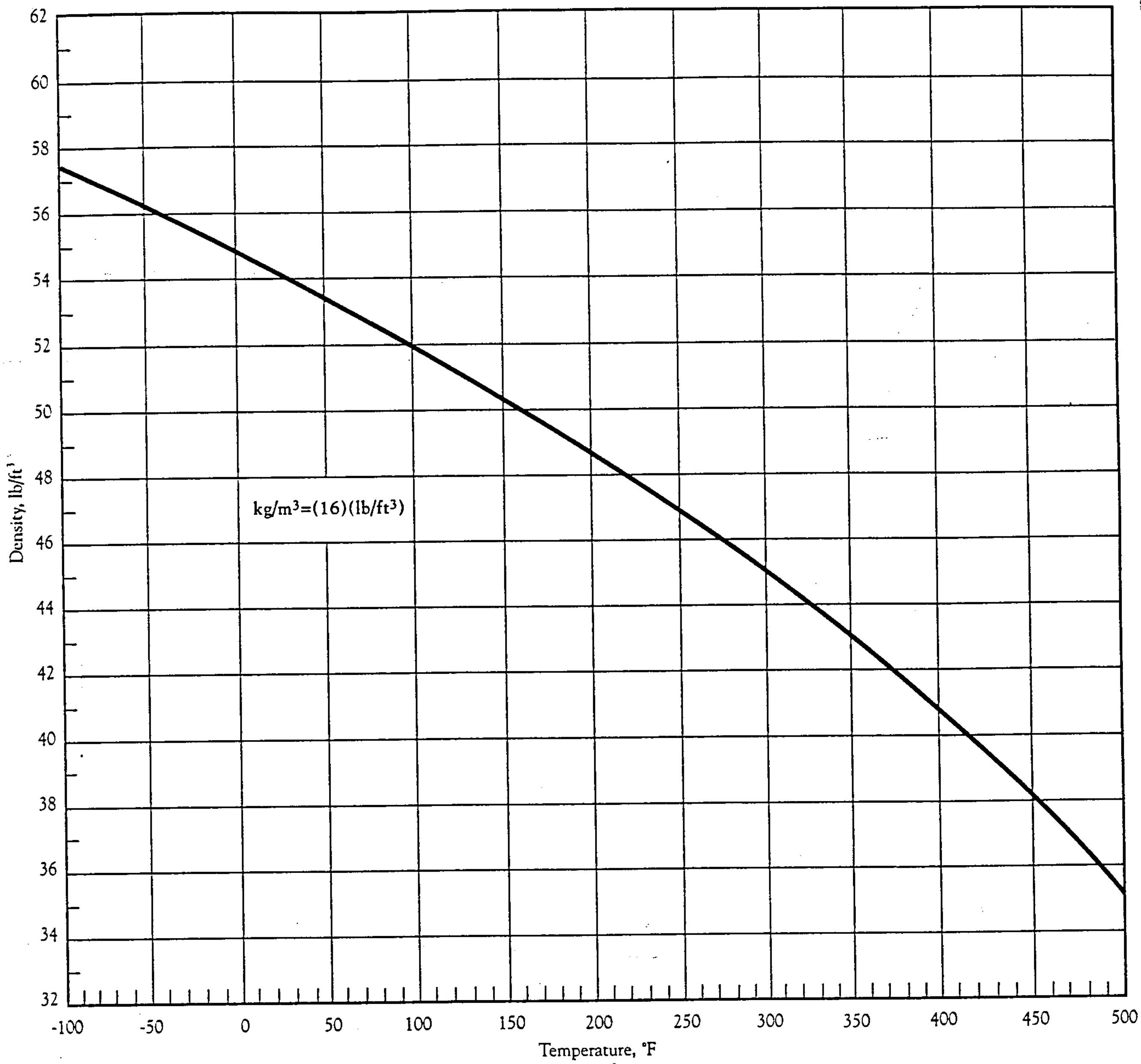


Figure 7—Thermal Volumetric Expansion of SYLTHERM XLT Fluid

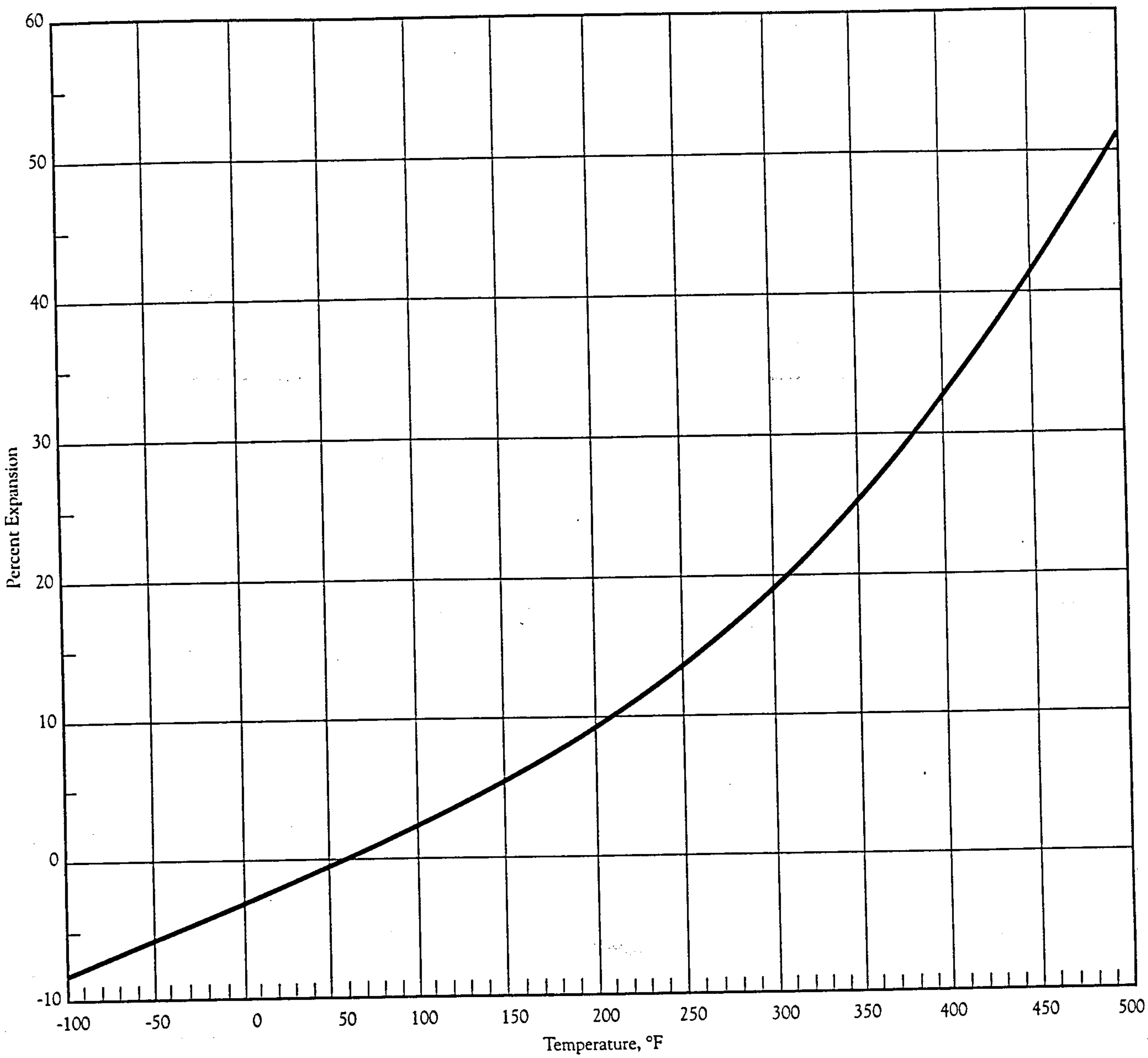


Figure 8—Heat Capacity of SYLTHERM XLT Fluid

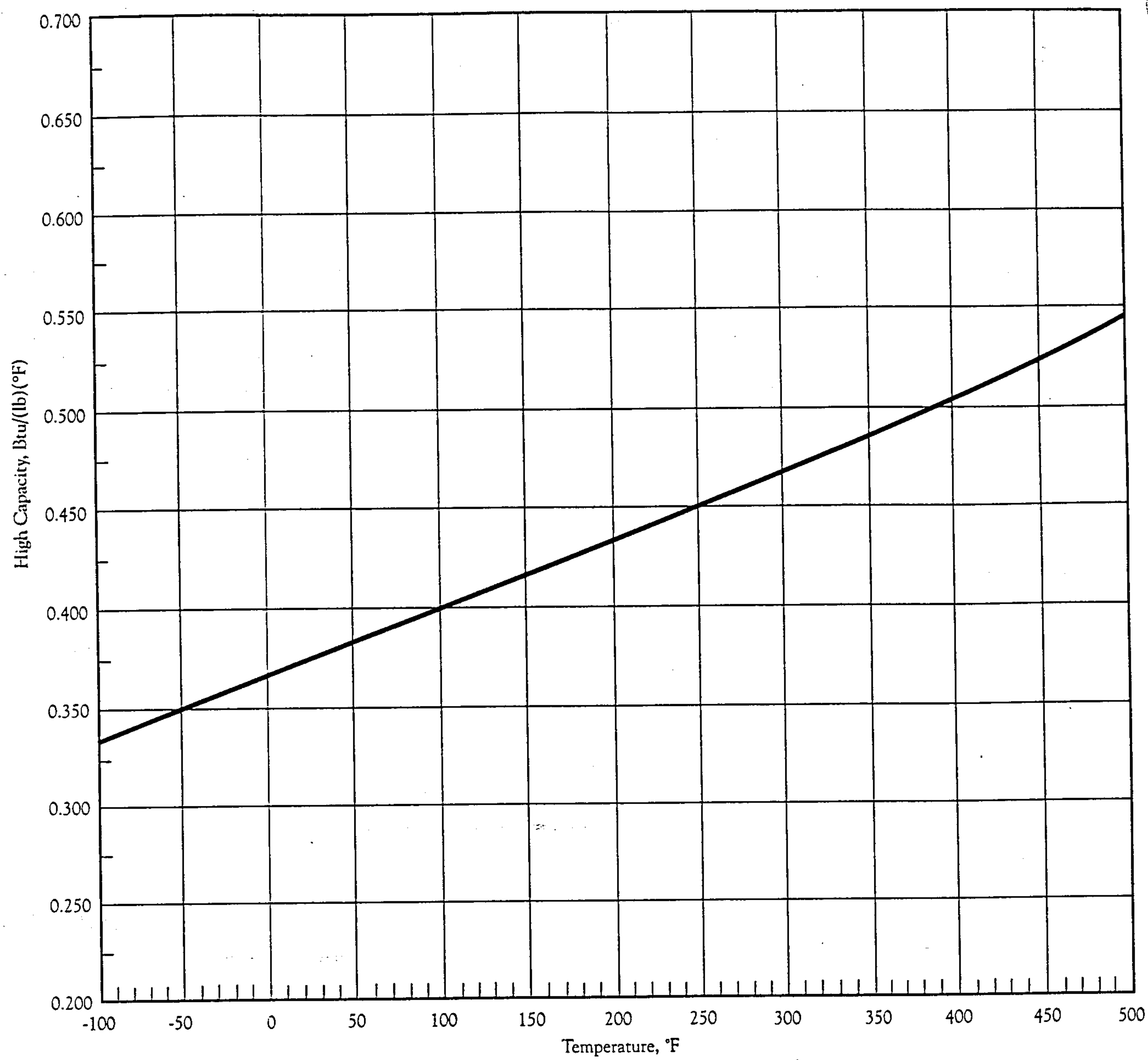


Figure 9—Heat of Vaporization of SYLTHERM XLT Fluid[1]

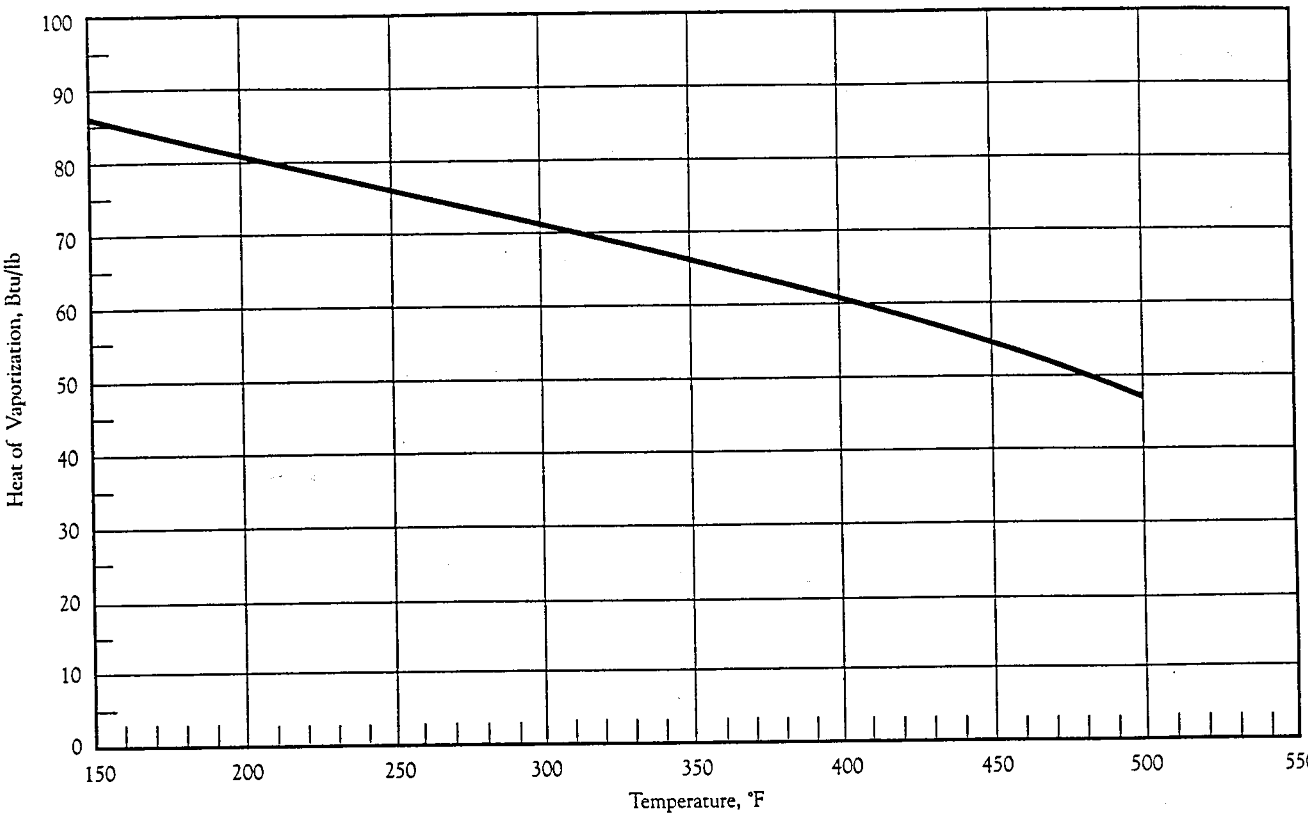
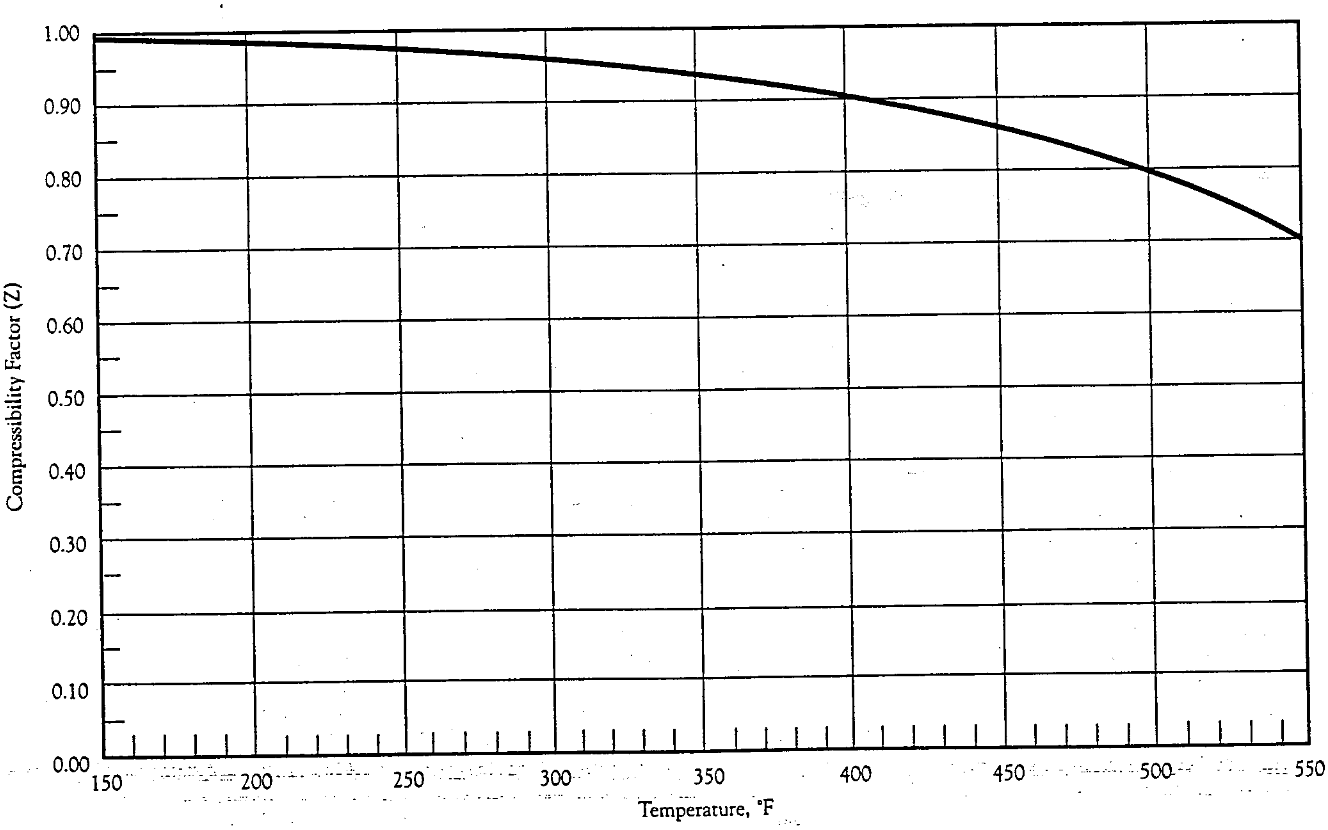


Figure 10—Compressibility Factor (Z) of SYLTHERM XLT Fluid[1]



[1] Values are estimated using an equation of state.

Figure 11—Molecular Weight of Vapor of SYLTHERM XLT Fluid[1]

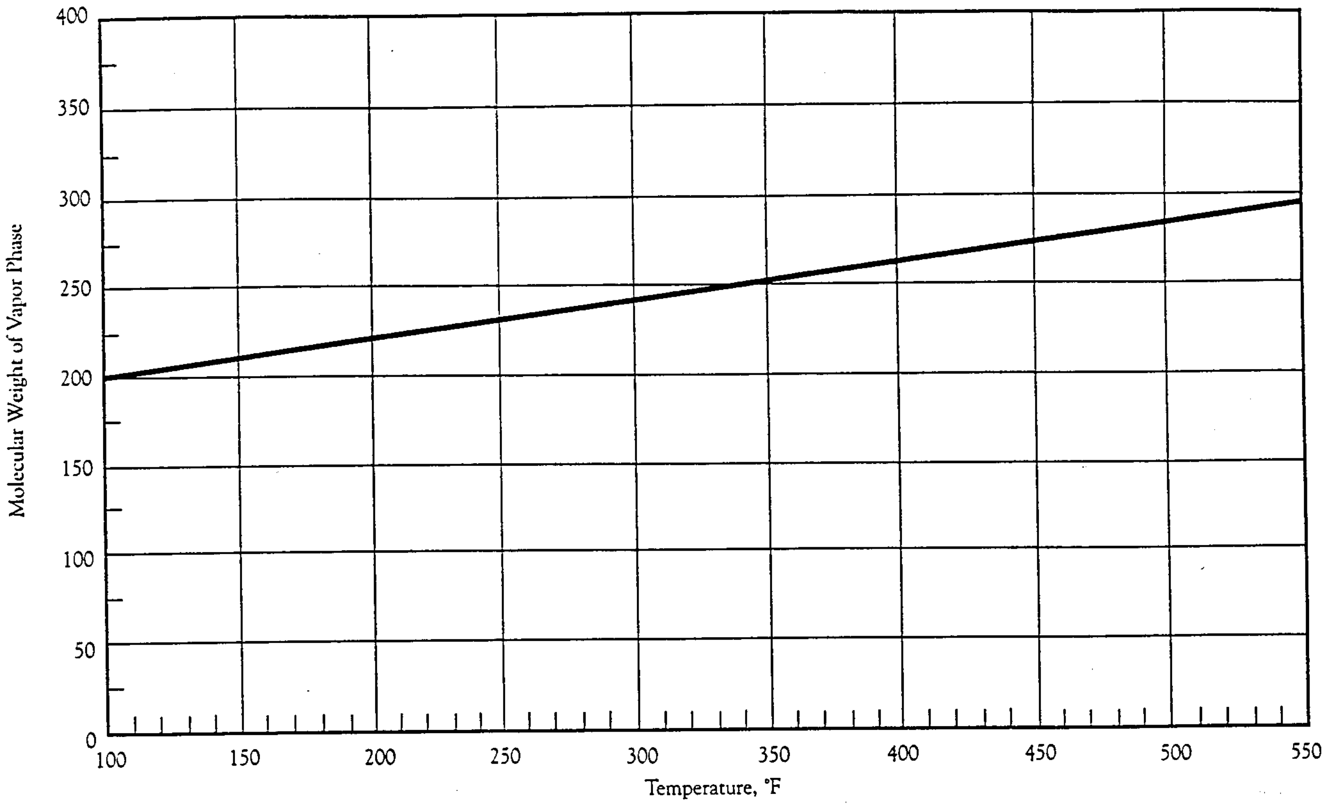
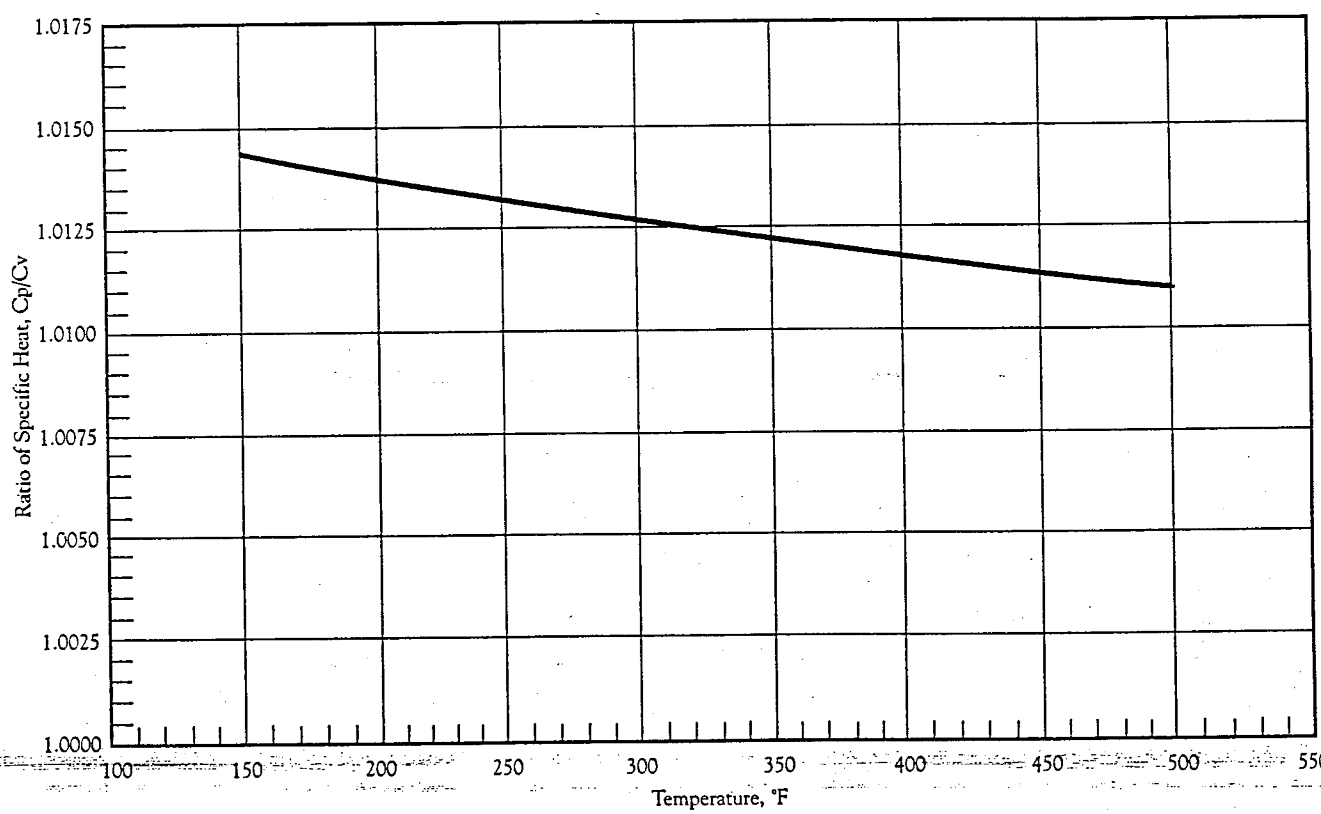


Figure 12—Calculated Specific Heat Ratios for Vapors of SYLTHERM XLT Fluid[1]



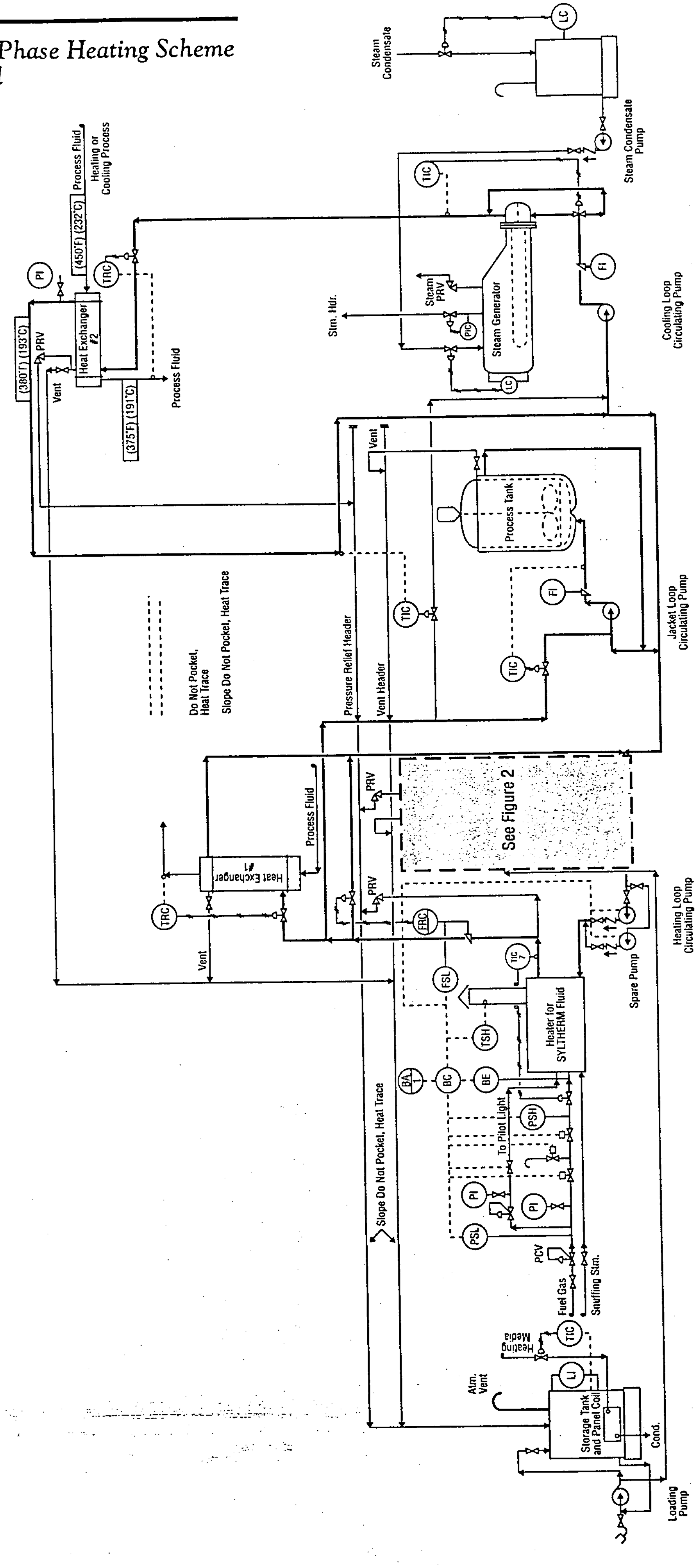
[1] Values are estimated using an equation of state.

Figure 13—Typical Liquid Phase Heating Scheme Using SYLTHERM XLT Fluid

Principal Circuits with SYLTHERM Fluid

Electrical Lines

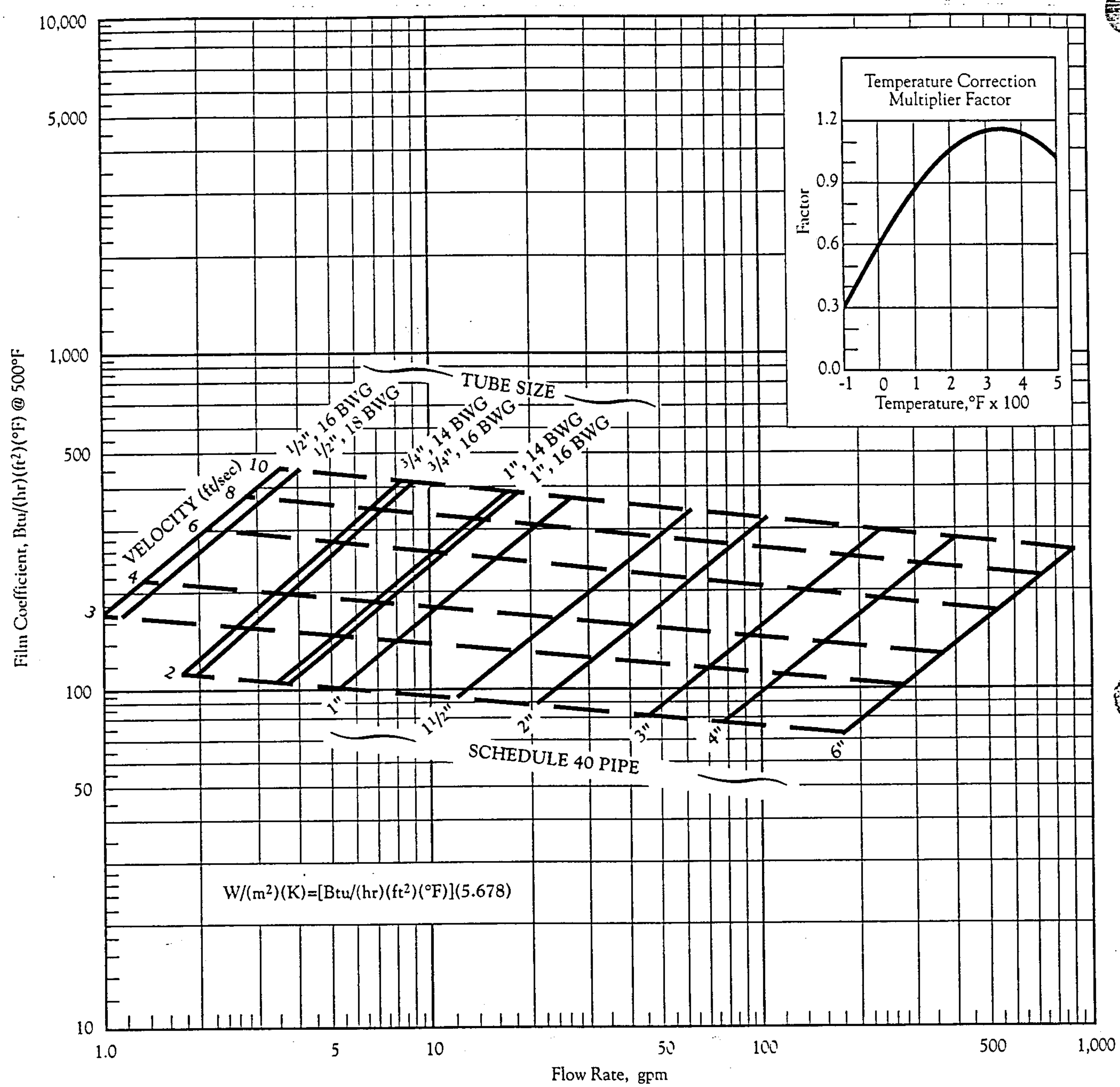
Instrument Air Lines



Instrument Legend

- BA – Burner Alarm
- BC – Burner Control
- BE – Burner Element (Fire-Eye)
- FI – Flow Indicator (Orifice)
- FRC – Flow Recording Controller
- FSL – Flow Switch Low
- LC – Level Controller
- PVC – Pressure Control Valve
- PI – Pressure Indicator
- PIC – Pressure Indicating Controller
- PRV – Pressure Relief Valve
- PSH – Pressure Switch High
- PSL – Pressure Switch Low
- TIC – Temperature Indicating Controller
- TRC – Temperature Recorder Controller
- TSH – Temperature Switch High

Figure 14—Liquid Film Coefficient of SYLTHERM XLT Fluid



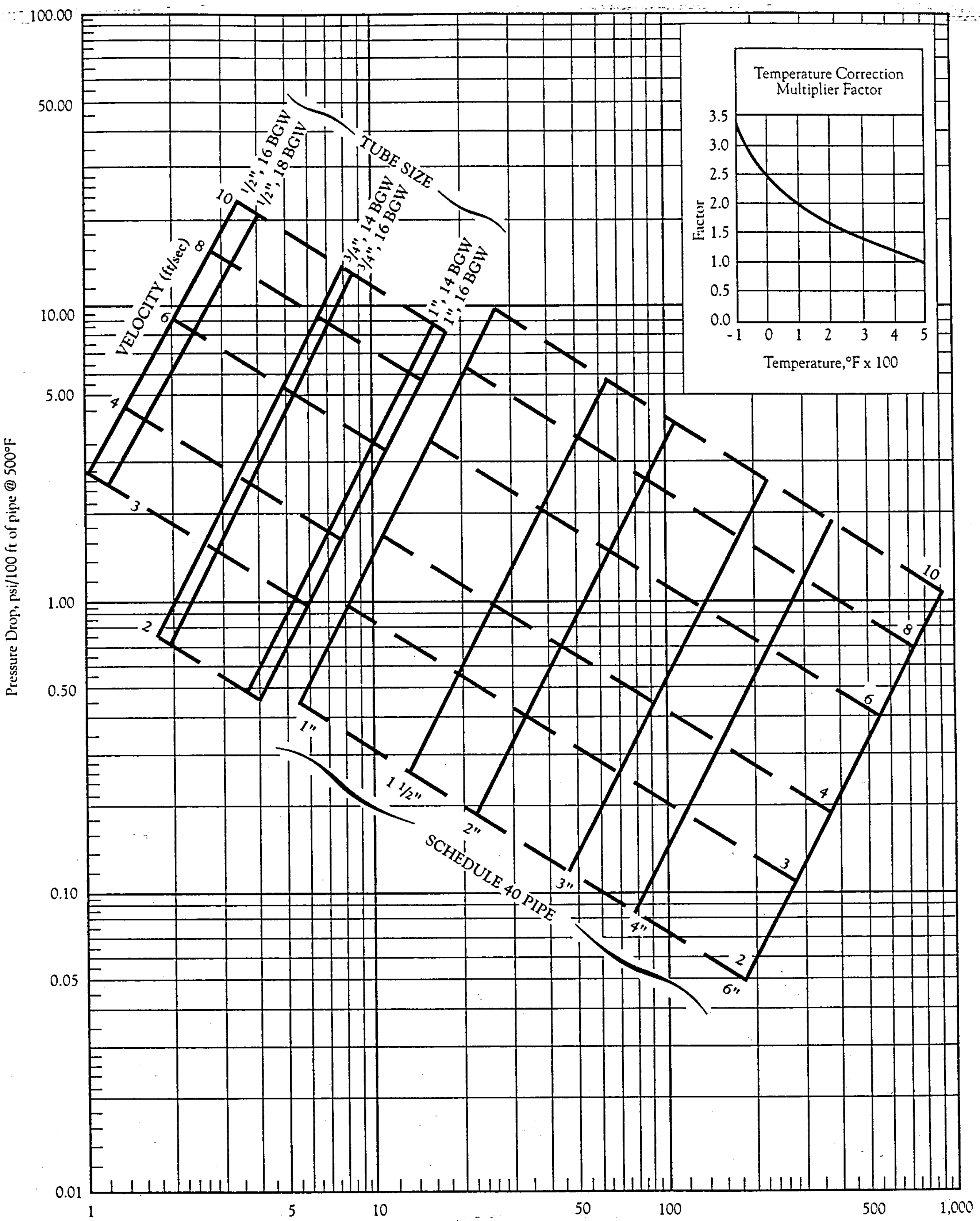
Sieder and Tate equation
Process Heat Transfer,
D.Q. Kern (1950) p. 103

$$\frac{\bar{h}_i d_i}{k} = 31.06 \left(\frac{d_i G}{\mu}\right)^{0.8} \left(\frac{C_p \mu}{k}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Chart based on $\left(\frac{\mu}{\mu_w}\right)^{0.14} = 1$

Note: The values in this graph are based on the viscosity of fluid as supplied. A reduction in viscosity as the fluid ages at high temperature can increase the coefficient by up to 15%. Contact your Dow TS&D representative if more information is needed.

Figure 15—Frictional Pressure Drops of SYLTHERM XLT Fluid



Conversion Factor:

gal/min = $(m^3/m)(4.403)$
m bar/10m = (psi/100ft)(0.2102)

DOW CORNING

new product information

==

SYLTHERM XLT™ HEAT TRANSFER LIQUID

Type.	Dimethylsiloxane polymer
Physical Form.	.Low-viscosity liquid
Color	.Clear
Special Properties . .	.Normal operating range from -100 to 500 F (-73 to 260 C) with film temperatures to 550 F (288 C); is noncorrosive; odorless; essentially non-toxic, and operates in heat transfer systems without fouling
Primary use . .	Low temperature, liquid-phase heat transfer liquid

==

DESCRIPTION

SYLTHERM XLT™ Heat Transfer Liquid is a low-viscosity liquid specially designed for use as a low-temperature, liquid-phase heat transfer medium for -100 F to +500 F (-73 to 260 C) service. Its features include:

* Essentially non-toxic
* Nonfouling
* Noncorrosive
* Odorless
* Low freeze point
* Long life

These unique features make it an ideal candidate for single-fluid process heating and cooling systems in the pharmaceutical and fine chemical industries. Syltherm XLT has been designed to provide an environmentally safe, essentially non-toxic and odorless alternative to the organic heat transfer fluids (e.g., water/glycol solutions, diethylbenzene, citrus oils, etc.) that are presently used for this type of service. In addition, the wide operating temperature range and exceptional thermal stability of Syltherm XLT allow it to be used as a replacement for hot oils in many other applications.

24-622

DOW CORNING CORPORATION, MIDLAND, MICHIGAN 48640 TELEPHONE 517 496-4000

PERFORMANCE

SYLTHERM XLT heat transfer liquid demonstrates exceptional thermal stability over its operational temperature range of -100 F to 500 F. Maximum recommended film temperature is 550 F (288 C). Within its recommended use range, it will not degrade to solids or form any deposits on the inside surfaces of a heat transfer system. SYLTHERM XLT is also noncorrosive to the carbon steel piping and components that are utilized in these systems.

CONTAMINATION

SYLTHERM XLT has been shown not to be sensitive to contamination by common piping contaminants, including water (during start-up and dry-out operations), rust, millscale, lubricants, pipe dope, and small amounts of solvent and organic heat transfer fluid residue. SYLTHERM XLT is somewhat more sensitive to certain types of contamination when at elevated temperatures. Contamination by acids, bases or water can result in the formation of lower molecular weight cyclic siloxanes that can raise the freeze point of the liquid. Contamination by oxygen or other oxidants can result in crosslinking of polymer molecules and, if not corrected, can cause a gradual increase in viscosity. In order to minimize the likelihood of oxygen contamination, the system expansion tank should be provided with an inert gas (e.g. nitrogen) blanket.

TYPICAL PROPERTIES

Note: These values are not intended for use in preparing specifications.

Appearance	Crystal clear liquid
Viscosity at 77 F (25 C), cP	1.6
Flash Point, closed cup, typical	116 F (47 C)
Flash Point, open cup, typical	130 F (54 C)
Autoignition Point, ASTM D-2155	662 F (350 C)
Acid Number, typical	0.01
Freeze Point	< -135 F (-93 C)
Density at 77 F (25 C), lbs/gal	7.1
Specific Gravity at 77 F (25 C)	0.85

Specification Writers: Please contact Dow Corning Corporation, Midland, MI, (517) 496-4000, before writing specifications on this product.

PHYSICAL PROPERTIES OF SYLTHERM XLT HEAT TRANSFER LIQUID

Temperature F (C)	Vapor Pressure psia	Viscosity cP	Density lbs/ft^3	Heat Capacity BTU/lb-F	Thermal Conductivity BTU/hr-ft-F
-100 (-73)	0.00	12.6	57.8	0.336	0.0651
-75 (-59)	0.00	8.13	57.0	0.345	0.0646
-50 (-46)	0.00	5.53	56.3	0.354	0.0641
-25 (-32)	0.00	3.94	55.6	0.362	0.0635
0 (-18)	0.00	2.91	54.9	0.370	0.0630
25 (-4)	0.00	2.22	54.1	0.379	0.0625
50 (10)	0.01	1.74	53.3	0.388	0.0620
75 (24)	0.03	1.40	52.6	0.396	0.0614
100 (38)	0.08	1.14	51.8	0.404	0.0609
125 (52)	0.17	0.952	51.0	0.413	0.0604
150 (66)	0.36	0.805	50.1	0.422	0.0599
175 (79)	0.68	0.689	49.3	0.430	0.0594
200 (93)	1.21	0.598	48.4	0.438	0.0588
225 (107)	2.04	0.524	47.5	0.447	0.0583
250 (121)	3.29	0.463	46.6	0.456	0.0578
275 (135)	5.09	0.413	45.7	0.464	0.0573
300 (149)	7.59	0.371	44.7	0.473	0.0568
325 (163)	10.96	0.336	43.7	0.481	0.0562
350 (177)	15.40	0.306	42.6	0.490	0.0557
375 (191)	21.10	0.280	41.5	0.498	0.0552
400 (204)	28.27	0.258	40.4	0.507	0.0547
425 (218)	37.14	0.238	39.1	0.515	0.0542
450 (232)	47.91	0.222	37.8	0.524	0.0536
475 (246)	60.80	0.207	36.6	0.532	0.0531
500 (260)	76.03	0.193	35.2	0.541	0.0526

REGRESSION EQUATIONS FOR PHYSICAL PROPERTY DATA

The regression equations for SYLTHERM XLT heat transfer liquid are listed below. When using these equations, it is important to preserve the accuracy of the coefficients to ensure the precision of the calculated value.

NOTE: T = degrees Rankine in all equations

Vapor pressure (psia):

Natural Log Pressure = A - B/(T+C) (Antoine Equation)

A = 11.31412960
B = 5628.28781546
C = -154.0

Viscosity (cP):

Natural Log Viscosity = A + B/T

A = -4.15321471
B = 2403.57403897

Density (lb/ft^3):

Density = A + B*T/100 + C*(T/100)**2 + D*(T/100)**3

A = 70.46750502
B = -4.43026844
C = 0.35772178
D = -0.02906877

Heat Capacity (BTU/lb-R):

Heat Capacity = A + B*(T/1000)

A = 0.21423227
B = 0.34072118

Thermal Conductivity (BTU/hr-ft-R):

Thermal Conductivity = A + B*(T/1000)

A = 0.07259731
B = -0.020838365

SYSTEM DESIGN INFORMATION

Many system design practices and recommendations found in the following literature are applicable to SYLTHERM XLT:

* SYLTHERM® 800 Heat Transfer Liquid Design Guide, Form No. 22-964C-88
* SYLTHERM® 800 Heat Transfer System Design Checklist, Version 2.2, Form No. 24-249-85

NOTE: Some of the information contained in the above literature applies to higher operating temperatures (up to 750 F){399 C} and pressures. Other operating procedures and equipment may be suitable for use with SYLTHERM XLT at low temperatures. Contact the SYLTHERM Technical Support Group for recommendations on specific system design requirements.

SAFE HANDLING INFORMATION

SYLTHERM XLT heat transfer liquid is neither an eye nor skin irritant and contains no OSHA-listed hazardous ingredients. Direct contact with the eye may cause some temporary discomfort, with some redness and dryness similar to the effects of windburn.

MATERIAL SAFETY DATA SHEETS

A Material Safety Data Sheet on SYLTHERM XLT is available on request from Dow Corning Corporation, Midland, MI 48686-0994 and will be supplied with all samples.

PACKAGING

SYLTHERM XLT heat transfer liquid is routinely supplied in 375-lb (170-kg) containers, net weight, and in bulk quantities. One-pound (0.45-kg) samples are available for evaluation and testing.

TECHNICAL SUPPORT AND ASSISTANCE

Dow Corning has a SYLTHERM® Technical Support Group to assist in designing new heat transfer systems or retrofilling existing systems. Dow Corning also provides a fluid monitoring service for users of SYLTHERM XLT heat transfer liquid. The user periodically sends in a representative sample for testing. Results, along with appropriate comments, are reported to ensure top performance. Contact Dow Corning for details or additional technical assistance:

SYLTHERM® Technical Support Group
Mail No. C40B00
P.O. Box 994
Midland, MI 48686-0994 U.S.A

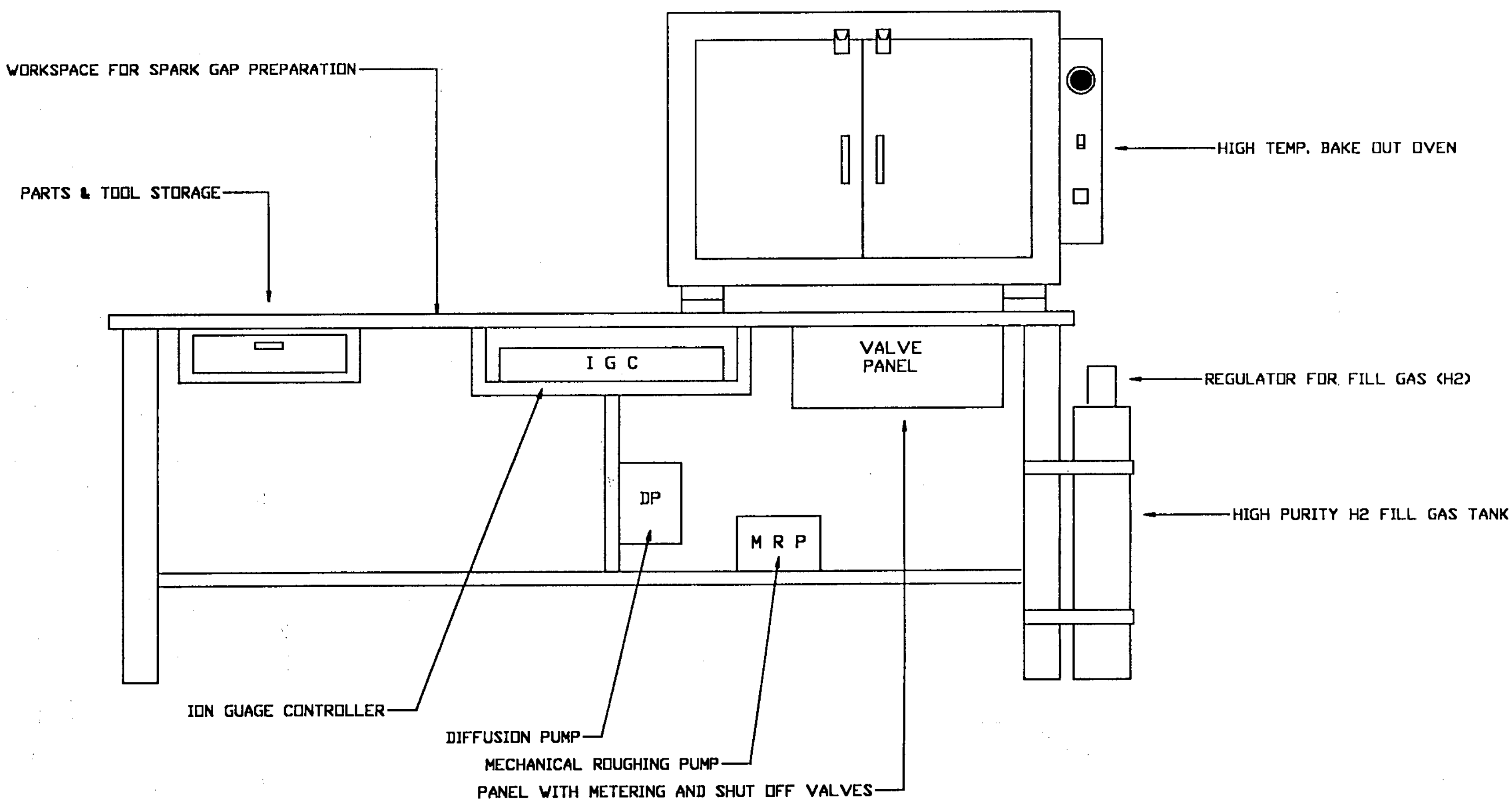
Phone: (517) 496-6000
Telefax: 517-496-5324
Telex: 227450

Product Emergencies: (517) 496-5900

WARRANTY INFORMATION - PLEASE READ CAREFULLY

Dow Corning believes that the information and recommendations in this publication are accurate as of June 1988. Contact Dow Corning for any information published after that date. It is the buyer's responsibility to determine the appropriateness of this product for the buyer's specific end use and to obtain all required clearances. DOW CORNING SPECIFICALLY DISCLAIMS ANY LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Suggestions of uses should not be taken as an inducement to infringe any patents.

PUMP STATION



REVISIONS

LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		

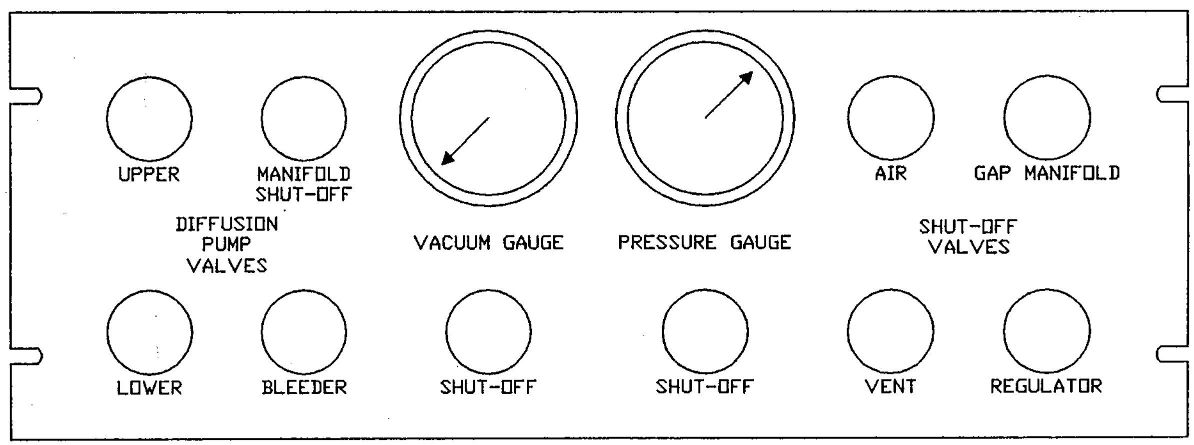
CONTRACT/JOB NUMBER

C. C. E.

GAS FILL STATION
BLOCK DIAGRAM

CAGE CODE	DRAWING NO.	REV
0Z887	MTD610-22	A

SCALE | WEIGHT | SHEET OF



REVISIONS

LTR	DESCRIPTION	DATE	APVD

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APPLICATION

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METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | ∠±0.5°

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2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN		
CHKR		
APPD		

CONTRACT/JOB NUMBER

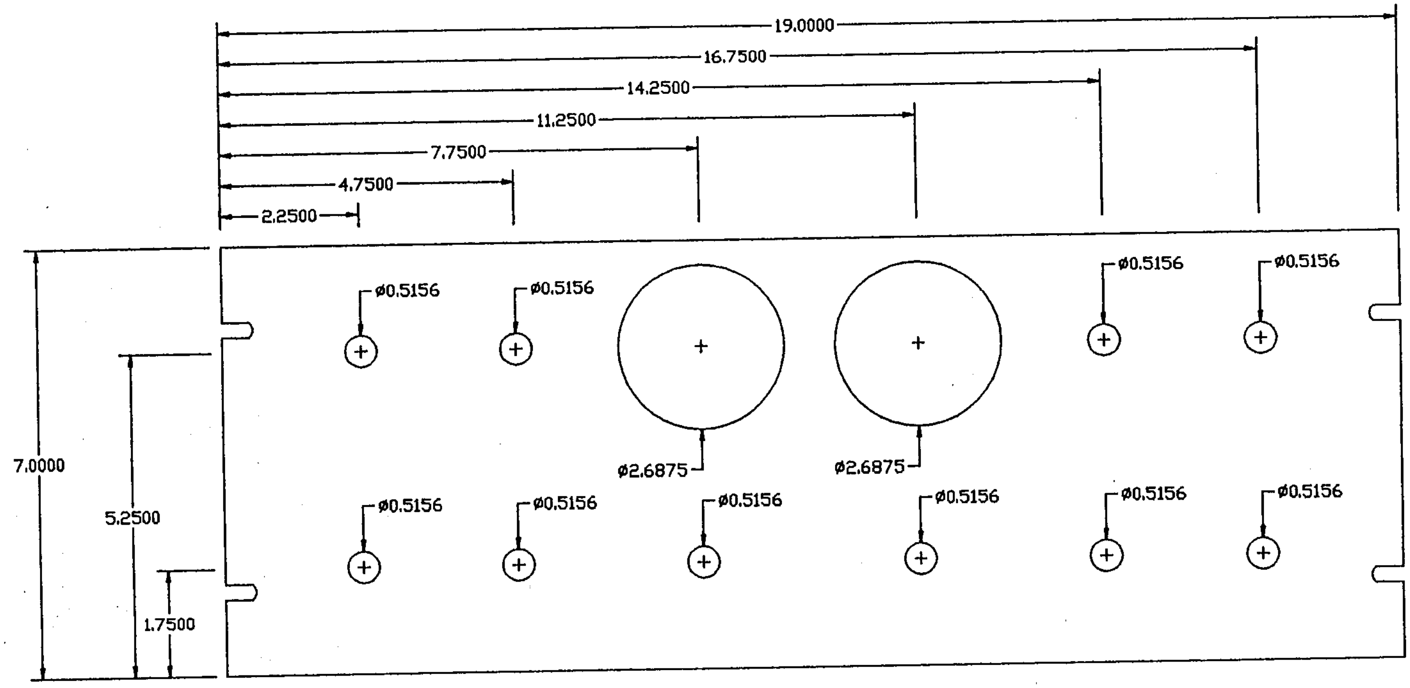
C. C. E.

VACUUM AND FILL GAS
VALVE PANEL

SIZE	CAGECO 0Z087	DRAWING NO. MDT610-17	REV A

SCALE | WEIGHT | SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | <±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

	DATE
DRAWN	
CHKR	
APPD	
CONTRACT/JOB NUMBER	

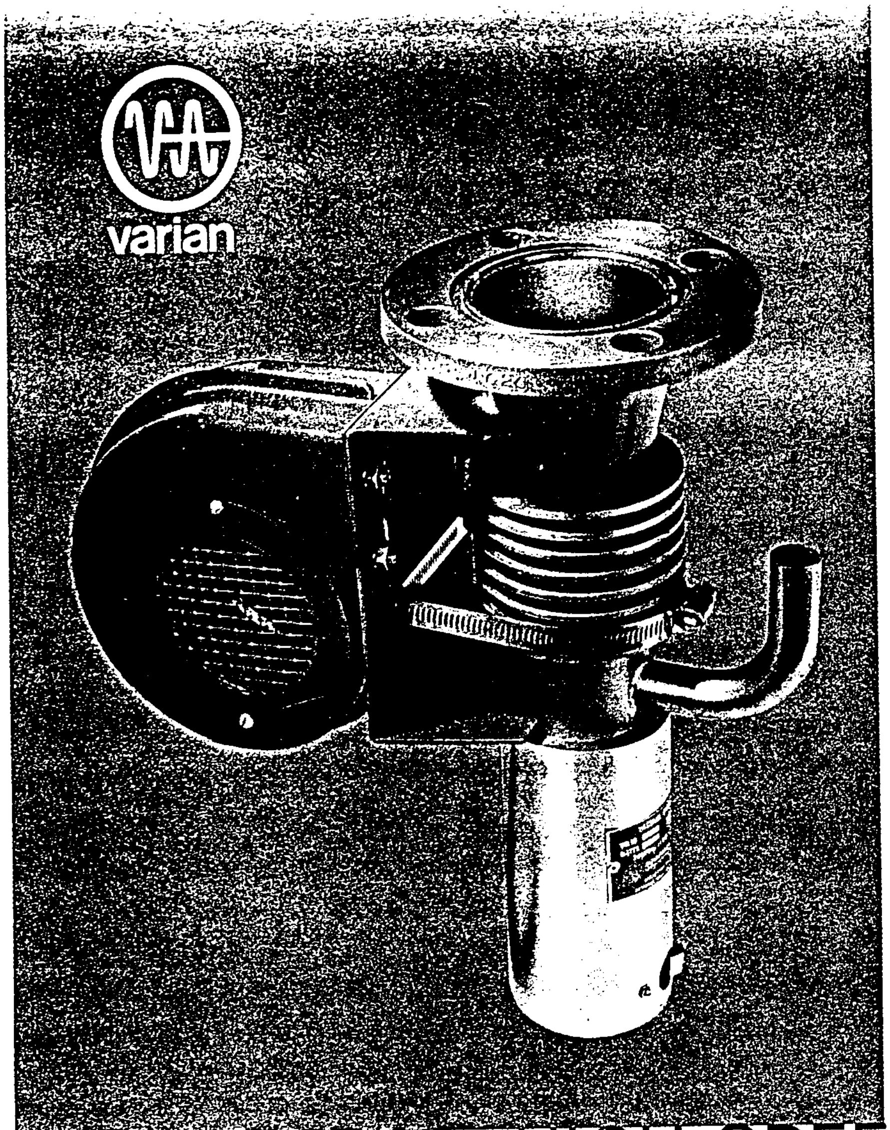
C. C. E.

VACUUM AND FILL GAS
VALVE PANEL

SIZE	CAGECO 0Z887	DRAWING NO. MDT610-18	REV A
SCALE	WEIGHT	SHEET	OF

GAS FILL PARTS LIST

ITEM	DESCRIPTION	MANUFACTURER	QUANTITY	PRICE	EXTENDED
1	"1" SERIES NEEDLE VALVE W/ BLACK HANDLE PART # SS-1KS4-A-BK	SWAGELOK WHITEY	2	$55.10	$110.20
2	"1" SERIES NEEDLE VALVE W/ YELLOW HANDLI PART # SS-1KS4-A-YW	SWAGELOK WHITEY	2	$55.10	$110.20
3	"1" SERIES NEEDLE VALVE W/ GREEN HANDLE PART # SS-1KS4-A-GR	SWAGELOK WHITEY	2	$55.10	$110.20
4	"1" SERIES NEEDLE VALVE W/ BLUE HANDLE PART # SS-1KS4-A-BL	SWAGELOK WHITEY	2	$55.10	$110.20
5	"1" SERIES NEEDLE VALVE W/ RED HANDLE PART # SS-1KS4-A--RD	SWAGELOK WHITEY	1	$55.10	$55.10
6	"1" SERIES NEEDLE VALVE W/ ORANGE HANDLI PART # SS-1KS4-A-OG	SWAGELOK WHITEY	1	$55.10	$55.10
7	1/4" TUBE TO 1/4" NPT FEMALE BRANCH TEE PART # SS-400-3TTF	SWAGELOK	1	$19.90	$19.90
8	1/4 INCH TUBE UNION CROSS PART # SS-400-4	SWAGELOK	4	$29.30	$117.20
9	DIFFUSION PUMP 2 INCH, AIR COOLED PART # HSA VNS053	VARIAN	1	$775.00	$775.00
10	MECHANICAL VACUUM PUMP, 5.6 SCFM PART # 1402	WELCH	1	$815.00	$815.00
11	IONIZATION GAUGE 564 SERIES, 1in. TUBE PART # VNS605	VARIAN	1	$120.00	$120.00
12	ION GAUGE CONTROLLER MODEL 880 WITH THERMOCOUPLE GAUGE	VARIAN	1	$1,295.00	$1,295.00
13	OVEN, 455 deg. C, 208, 3ph 20x20x20 in. 10KW BLOWER PART # 3804A	LABLINE	1	$1,250.00	$1,250.00
14	WORK BENCH WITH DRAWER PART # 53-287AX	C&H	1	$201.50	$201.50
15	ASSEMBLY OF GAS FILL STATION	CCE	1	$600.00	$600.00
				TOTAL	$5,744.60



HSA 2-INCH DIFFUSION PUMP

FEATURES

- Air Cooled . . . no water required for cooling
- High Speed . . . 150 ℓ/s
- High Forepressure Tolerance . . . 0.50 Torr
- Low Backstreaming . . . 0.05 cc/hr. without baffle
- Inlet Baffle . . . optional
- Clean Operation
- Outstanding Reliability and Low Maintenance . . . provided by full fractionating design

AIR-COOLED...HIGH SPEED...VERSATILE

GENERAL DESCRIPTION

The HSA 2-inch air-cooled diffusion pump is an extremely rugged, general purpose pump with a continuous operating range of 2.5×10^{-3} Torr to less than 5×10^{-8} Torr. High pumping speed combined with high forepressure tolerance make the HSA ideal for laboratory or production applications requiring fast cycling.

An exclusive jet and boiler assembly design minimizes the possibility of fluid loss if the pump is exposed to high air pressure. Electrical connectors (male part) are provided for the pump heater and the cooling fan. A five-foot long fan cord is provided for versatility of installation. A large "squirrel cage" blower and copper fins are brazed to the pump body to ensure efficient cooling.

The blower can be rotated around an arc of 270° to facilitate mounting the pump into a system. The cartridge type heater can be easily removed through a port in the side of the heat reflector, eliminating the need for clearance below the pump.

OPTIONAL BAFFLE - COLD CAP

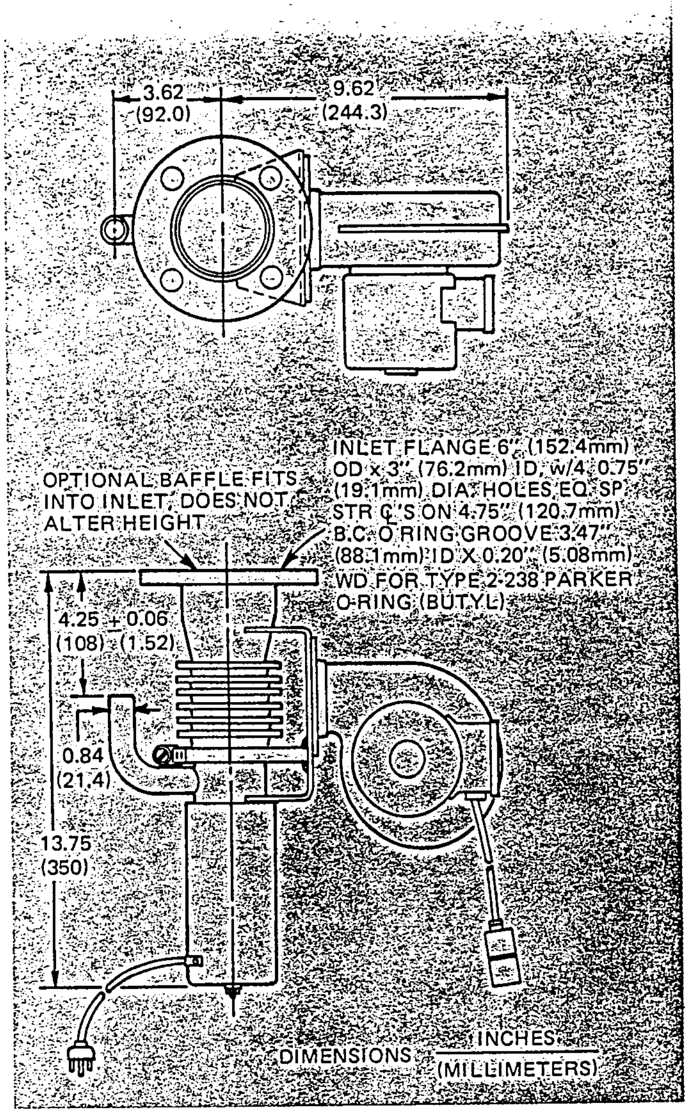
NO INCREASE IN PUMP HEIGHT

For critical applications, an optional conduction-cooled baffle is available. The baffle, which fits into the inlet of the pump, reduces backstreaming so effectively that the residual rate cannot be measured by AVS standards.

lexington vacuum division/121 hartwell avenue/lexington, massachusetts 02173
varian SpA/via varian, 10040 leini/torino, italy
varian GmbH, D-7000/stuttgart-vaihingen/brietwiesenstrasse 9, west germany

SPECIFICATIONS

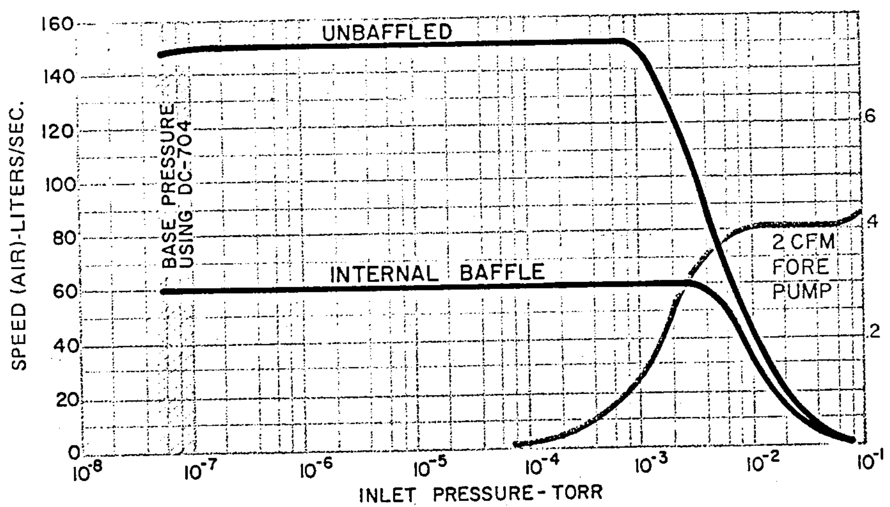
Speed (unbaffled)	150 ℓ/s at < 1×10^{-3} Torr
(baffled)	60 ℓ/s at < 3×10^{-3} Torr
Normal Operating Range ..	2×10^{-3} to the 10^{-8} Torr range
Ultimate Pressure	5×10^{-8} Torr (DC-704)
Maximum Forepressure ...	No Load – 0.5 Torr Full Load – 0.4 Torr
Recommended Forepump .	1 CFM (for throughput less than 0.15 Torr ℓ/sec.) 2 CFM (for throughput up to 0.4 Torr ℓ/sec.)
Backstreaming Rate ..... (at inlet flange)	.05 cc/hr. or .02 mg/cm^2/min. unbaffled. With baffle, backstreaming rate not measurable by AVS standard
Warm-up Time	10 minutes
Cooling Time	40 minutes
Fluid Charge	50 cc
Power (heater nominal)...	325w, 120v (240v optional)
(blower)	1/30 HP, 120v
Height	13¾" (350 mm)
Body	Stainless Steel
Jet Assembly	3 stage, aluminum and brass
Baffle (optional)	Copper – Optically tight, fits inside 3" (76.2 mm) ID inlet of pump
Heater	Removable platen with replaceable cartridge
Weight	16 lbs. including blower



PUMPING SPEED

OF MODEL HSA

DIFFUSION PUMP



ORDERING INFORMATION

HSA Air-cooled Diffusion Pump,
120 V heater and 110 V blower ..... Order No. 0159-85260-301

HSA Air-cooled Diffusion Pump,
240 V heater and 110 V blower ..... Order No. 0159-85260-302

Inlet Baffle .... Order No. 0181-82291-301

VAC 1061B (Printed In U.S.A.) 679 Section 2

HOW TO ORDER

Orders and requests for additional information should be addressed to the nearest Varian District Office or to Varian Associates, Lexington Vacuum Division, 121 Hartwell Ave., Lexington, Massachusetts 02173. Address European inquiries to nearest Varian District Office or to Varian GmbH, D-7000, Stuttgart-Vaihingen, Breitwiesenstrasse 9, West Germany, or to Varian SpA, Via Varian, 10040 Leini, Torino, Italy.

TRIGGER UNIT

C. C. E.
CUSTOMER: NSWC
TITLE : T-610 TRIGGER GENERATOR
BILL NO: MT610-1

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345
31-Jan-95

DESIG.	P/N	QTY.	DESCRIPTION	MFR	MFR PART NO.
C1		3	4000pf, 20KVDC CERAMIC CAPACITOI	TDK	UHV-3A
C2			S/A C1		
C3			S/A C1		
C4		5	1300pf, 40KVDC CERAMIC CAPACITOI	TDK	UHV-8A
C5			S/A C4		
C6			S/AC4		
C7			S/A C4		
C8			S/A C4		
C9		4	100pf, 40KVDC CAPACITOR	TDK	UHV-241A
C10			S/A C9		
C11			S/A/ C9		
C12			S/A C9		
C13		1	2.0uf, 15KVDC CAPACITOR	CSI	15M2Y0
C14	21011	1	0.01uf, 50VDC MONO-CERAMIC	SPRAGUE	1C10X7R103K050B
CR1		4	30KV, 0.40A DIODE	EDI	RVF-30
CR2		1	S/A CR1		
CR3		1	S/A CR1		
CR4			S/A CR1		
CR5		2	50KV, 2.25A RECTIFIER DIODE	EDI	KHP-50
CR6			S/A CR5		
CR7		1	25KV, 2.25A RECTIFIER DIODE	EDI	KHP-25
F1	22006	1	FUSE, 1.5A TIME DELAY	COOPER	MDL-1.5
F2	22011	1	FUSE, 5A TIME DELAY	COOPER	MDL-5
F3		1	FUSE, 0.25A TIME DELAY	COOPER	MDL-.25
FH1	12001	3	FUSE HOLDER, PANEL MOUNT	LITTLEFUSE	342012A
FH2			S/A FH1		
			S/A FH1		
FL1		1	FILTER, LINE 20A	CORCOM	20VR1
J1		4	CONNECTOR, BNC PANEL MOUNT	KINGS	KC-79-94
J2			S/A J1		
J3			S/A J1		
J4			S/A J1		
J5		3	SOCKET, RELAY 8 PIN OCTAL	P&B	27E122
J6			S/A J5		
J7			S/A J5		
K1		1	CIRCUIT BREAKER, 15A PANEL MT.	HEINEMANN	TX1-P15-U00-WH2
K2		2	RELAY, G. P. DPDT 24VDC COIL	MAGNECRAFT	W250CPX-7
K3			S/A K2		
K4		1	RELAY, DELAY ON MAKE 0-15min	MAGNECRAFT	W211ACPSOX-60
K5		1	RELAY, H. V. DUMP	ROSS	E-60-NC-80
L1		1	CHOKE, CHARGING 5Hy	MAG-CAP	
M1	42023	1	PANEL METER, LED 3.5 DIGIT	SIMPSON	24602
R1		3	10Meg OHM, 10W, 0.1% RESISTOR	CADDOCK	MG810-10M
R2			S/A R1		
R3	24110	1	20K OHMS, .25W, 1% RESISTOR	DALE	RN60C2002
R4			S/A R1		
R5	24025	1	10K OHM, 0.5W, 1% RESISTOR	CGW	RN65D1002FJ
R6		2	20K OHM, 225W, RESISTOR	OHMITE	L225J20K
R7			S/A R6		
R8		1	20K OHM, 100W, RESISTOR	OHMITE	L100J20K
R9		1	150 OHM, 225W, RESISTOR	OHMITE	L225J150
R10		1	75 OHM, 225W, RESISTOR	OHMITE	L225J75R
R11		1	0.1 OHM, 50W, 1% SENSE RESISTOR	CLAROSTAT	CMC-50/0.1R
T1	52012	1	0-120VAC, 10A, VARIAC	STACO	1010
T2		1	POWER TRANSFORMER	MAG-CAP	
T3		1	HEATER TRANSFORMER	SIGNAL	12.8-12
T4		1	1:4 PULSE TRANSFORMER	MAG-CAP	
X1	17002	1	PANEL, 19" RACK, 15.75"H	BUD	SFA-1839
X2		1	ENCLOSURE, 15.75"H x 20.00"D	CCE	BXG610
V1		1	THYRATRON	LITTON	L4915

C. C. E.
CUSTOMER: NSWC
TITLE : T610 THYRATRON GRID PULSER P.S.
BILL NO: MT610

NAME/DATE:
CUSTOMER PO:
CONTRACT NO: N60921-94-C-A345
31-Jan-95

DESIG.	P/N	QTY.	DESCRIPTION	MFR	MFR PART NO.
C1	21009	9	0.01uf, 1KVDC CERAMIC DISK	SPRAGUE	5GAS10
C2			S/A C1		
C3			S/A C1		
C4			S/A C1		
C5	21019	1	20uf, 350VDC ALUM. ELECTROLYTIC	MALLORY	TC65
C6			S/A C1		
C7			S/A C1		
C8	21021	1	100uf, 35VDC ALUM. ELECTROLYTIC	MALLORY	TKR101M1VF11V
C9			S/A C1		
C10			S/A C1		
C11			S/A C1		
C12	21036	1	240pf, 50VDC MICA	CDE	CD10-FD241J03
C13	21035	1	10pf, 50VDC MICA	CDE	CD10-CD100D03
C14		1	5uf, 450VDC ALUM. ELECTROLYTIC	MALLORY	TC70
C15	21002	3	0.1uf, 600VDC POLYPROP.	SPRAGUE	715P10456LD3
C16			S/A C15		
C17			S/A C15		
CR1	31010	1	BRIDGE RECTIFIER, 1KV, 2A	FAGOR	FBP10
CR2	31001	10	DIODE, G/P 1KV (PIV)	MOTOROLA	1N4007
CR3	31020	1	DIODE, ZENER 8.2V (Vz) 0.5W (Pd)	MOTOROLA	1N4738
CR4			S/A CR1		
CR5			S/A CR1		
CR6			S/A CR1		
CR7			S/A CR1		
CR8			S/A CR1		
CR9	31004	1	DIODE, ZENER 4.7V (Vz) 5W (Pd)	MOTOROLA	1N5337B
CR10			S/A CR1		
CR11			S/A CR1		
CR12			S/A CR1		
CR13			S/A CR1		
Q1	32004	5	POWER TRANSISTOR, 40W (Pd)	MOTOROLA	TIP-50
Q2					
Q3					
Q4					
Q5					
R1	24001	5	4.7 OHM, 0.5W CC	A-B	RC20EB
R2	24033	2	270K OHM, 0.5W CC	A-B	RC20EB
R3	24002	2	47 OHM, 0.5W CC	A-B	RC20EB
R4	24086	1	100 OHM, 0.25W CC	A-B	RC07EB
R5	24161	1	8.25K OHM, 0.25W CC	A-B	RC07EB
R6	24091	1	330 OHM, 0.25W MF	DALE	RN60D8251F
R7	24134	1	18.2K OHM, .025W MF	DALE	RN60C18.2K
R8	24092	1	470 OHM, 0.25W CC	A-B	RC07CB
R9	24105	2	150K OHM, 0.25W CC	A-B	RC07CB
R10			NOT USED		
R11	24017	1	1.2K OHM, 0.5W CC	A-B	RC20EB
R12	24118	1	15K OHM, 0.25 CC	A-B	RC07CB
R13	24113	1	1.43K OHM, 0.25W MF	DALE	RN60D1431F
R14	24093	1	1K OHM, 0.25W CC	A-B	RC07CB
R15			S/A R9		
R16			NOT USED		
R17			S/A R2		
R18	24049	1	10 OHM, 1W CC	A-B	RC32GB
R19	24065	1	2.2K OHM, 2W CC	A-B	RC42HB
R20			S/A R1		
R21			S/A R1		
R22	24047	1	10Meg OHM, 0.5W CC	A-B	RC20EB
R23			NOT USED		
R24			S/A R3		
R25			S/A R1		
R26			S/A R1		
T1	52010	1	POWER TRANSFORMER	STANCOR	DSW-220
U1	33004	1	FLOATING V/C REGULATOR	MOTOROLA	MC1466L
VR1	36001	1	MOV VARISTOR, 130VRMS	HARRIS	V130LA20A

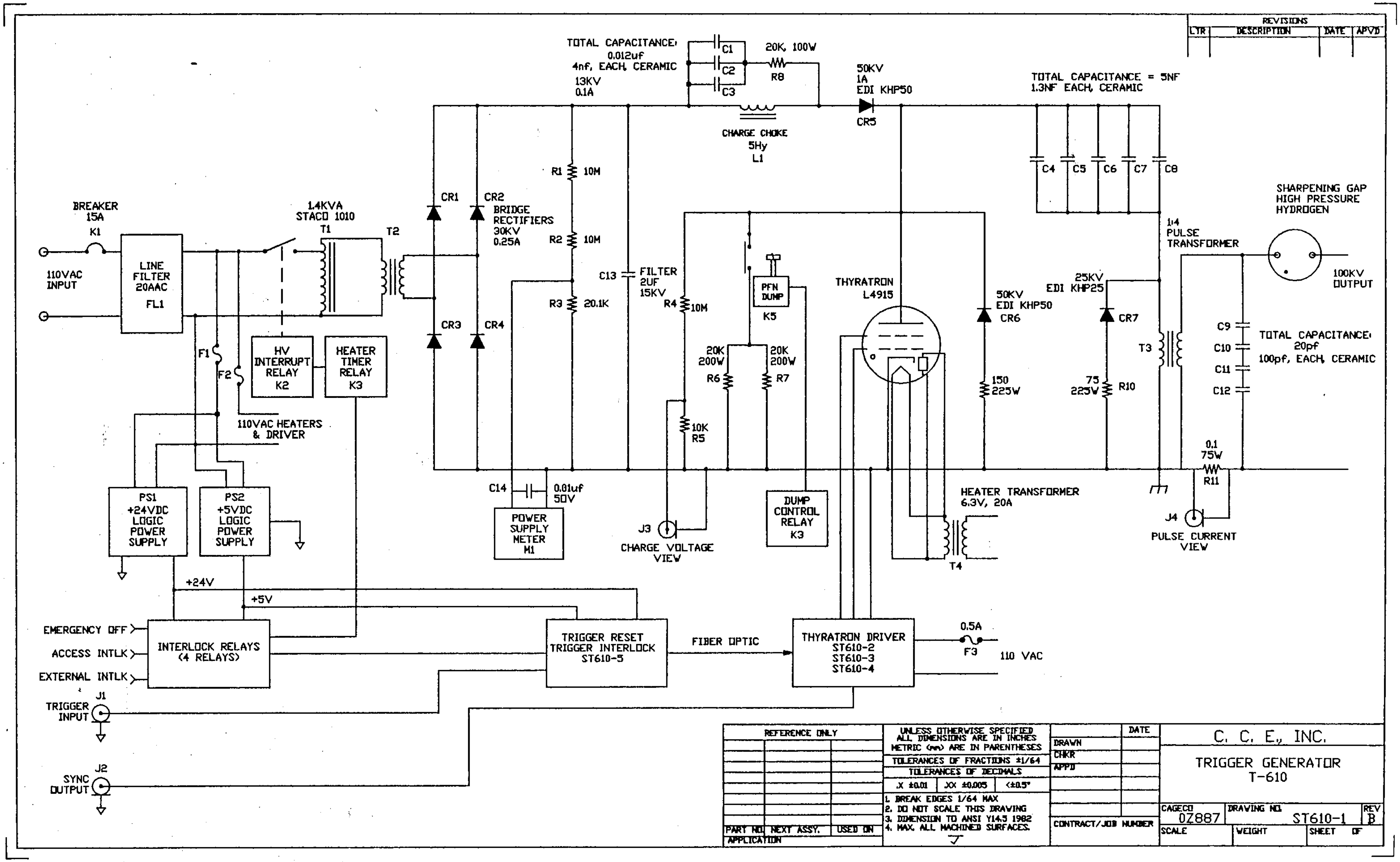
C. C. E.		NAME/DATE:	
CUSTOMER:	NSWC	CUSTOMER PO:	
TITLE :	T610 THYRATRON GRID PULSER	CONTRACT NO:	N60921-94-C-A345
BILL NO:	MT610		31-Jan-95

DESIG.	P/N	QTY.	DESCRIPTION	MFR	MFR PART NO.
A1	ST610-2	1	SCHEMATIC		
A2	ST610-3	1	THYRATRON DRIVER BOARD AND TRANSFORMER		
A3	ST610-4	1	POWER SUPPLY GRID PULSER		
C3	21021	2	100 uF 35VDC (VERTI ELECT)	MALLORY	TKR101M1VF11V
C4	S/A C3				
C5	21006	1	0.1uf, 50VDC (MONO CERAMIC)	SPRAGUE	1C20Z5U104M050B
C6	21011	1	0.01uf, 50VDC (MONO CERAMIC)	SPRAGUE	1C20Z5U103M050B
C7	21019	1	20uf, 350VDC (ALUM. ELECT.)	MALLORY	TC65
CR1	31001	1	DIODE, G/P 1KV (PIV)	MOTOROLA	1N4007
CR2	31019	1	ZENER DIODE, 5.1V(Vz), 0.5W (Pd)	MOTOROLA	1N5231B
CR3	31009	1	DIODE, Si/SWIT 100V (PIV)	TEXAS INST.	1N914B
F1	22003	1	FUSE, SLO-BLO, 0.5A	BUSS	MDL-1/2
FH1	12004	1	FUSEHOLDER	LITTLEFUSE	342012A
FL1	23010	1	FILTER, IN-LINE, 1A	CORCOM	1VK1
L1	51001	1	CHOKE, 60mH	ATLAS ENG.	AE11747
Q1	32002	1	TRANSISTOR, PNP, G/P	MOTOROLA	2N3250
R1	24082	1	10 OHM, 0.25W CC	A-B	RC07
R2	24099	1	10K OHM, 0.25W CC	A-B	RC07
R3	24116	1	3.9K OHM, 0.25W CC	A-B	RC07
R4	24165	1	8.2K OHM, 3W WW	DALE	RS-2B
U2	33005	1	REGULATOR, 5V, 0.5A, TO-220	MOTOROLA	78M05
U3	33044	1	F.O. RECIEVER, VERSALINK	H-P	HFBR-2523
U5	31010	1	RECTIFIER, BRIDGE, 1KV, 2A	FAGOR	FBP10
T1		1	PWR XFMR, 120V 0.2A	SIGNAL	PC120-200
T2		1	PWR XFMR, 56V 0.18A	SIGNAL	PC56-180
T3		1	PWR XFMR, 10V 0.44A	SIGNAL	DPC10-440

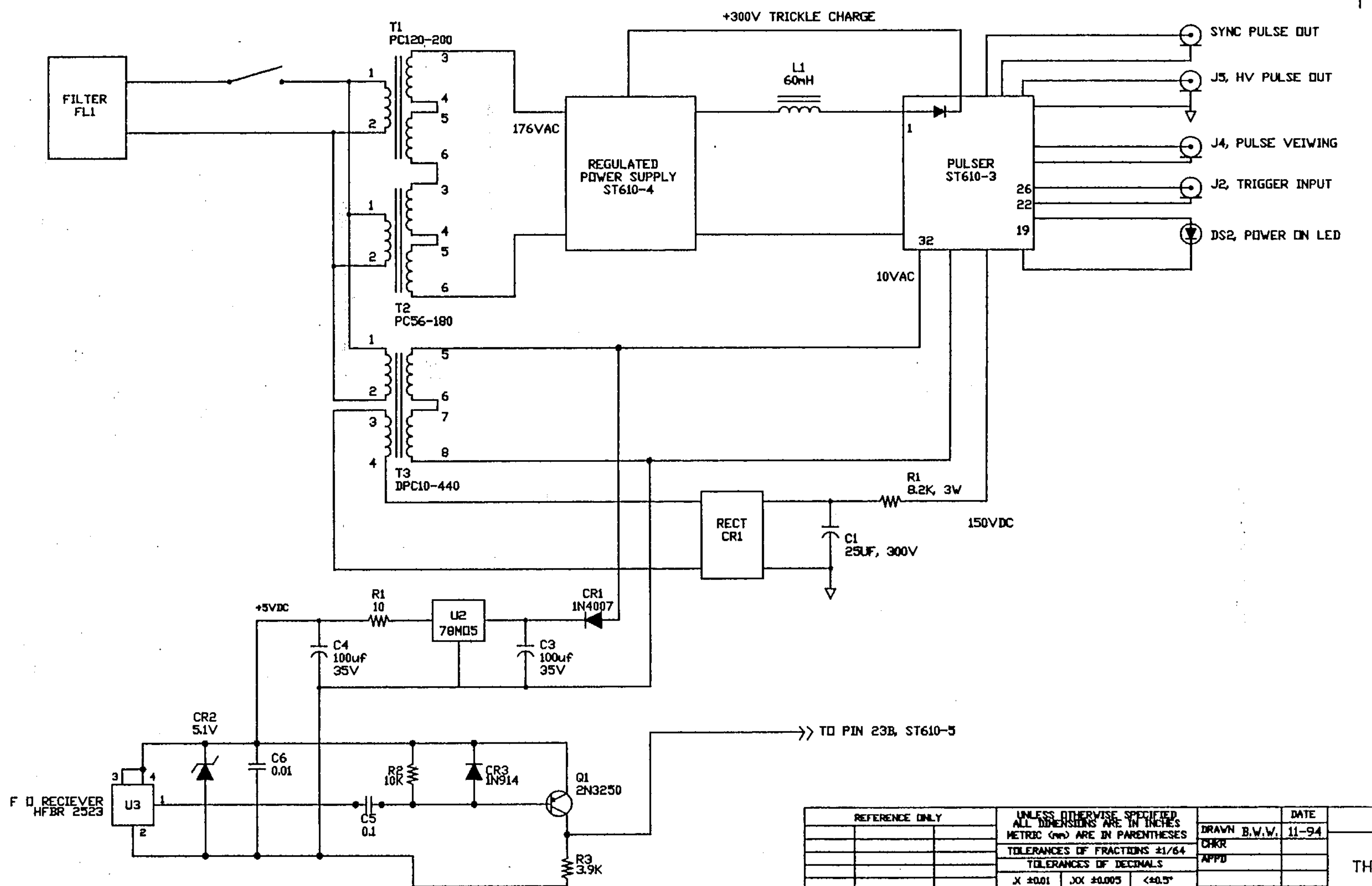
REF. A2 THYRATRON DRIVER BOARD AND TRANSFORMER

DESIG.	P/N	QTY.	DESCRIPTION	MFR	MFR PART NO.
REF	ST610-3	1	THYRATRON DRIVER BOARD AND TRANSFORMER		
REF	CLT610	1	COMPONENT LAYOUT		
REF	PWB16008	1	PC BOARD		
C1			NOT USED		
C2	21002	2	0.1uF 600VDC (POLYPROP)	SPRAGUE	715P10456LD3
C3			S/A C2		
C4	21001	1	0.047uF 600VDC (POLYPROP)	SPRAGUE	715P47356LD3
C5			N/U		
C6	21021	2	100 uF 35VDC (VERTI ELECT)	MALLORY	TKR101M1VF11V
C7			S/A C6		
C8	21006	2	0.1 uF 50VDC (MONO CERAM)	SPRAGUE	1C20Z5U104M050B
C9			S/A C8		
C10	21030	1	0.0068 uF 200VDC (POLYESTER)	SPRAGUE	192P682X9200
C11	21011	2	0.01 uF 50VDC (MONO CERAMIC)	SPRAGUE	1C10X7R103K050B
C12	21034	1	4.7uF 35VDC (TANTALUM)	SPRAGUE	196D475X9035JA1
C13			S/A C11		
C14	21007	1	1.0uF 50VDC (MONO CREAM)	SPRAGUE	2C25Z5U105M050B
C15	21005	1	68pF 1kVDC (CERAMIC DISK)	SPRAGUE	10TCCQ68
C16	21009	1	0.01uF 1kVDC (CERAM DISK)	SPRAGUE	5GAS10
C17	21042	1	12-100pF TRIMMER (MICA)	JOHANSON	9328
C18	21048	1	500PF 10KV CER DISK	SPRAUGE	100GAT50

CR1	31011	8 DIODE, F/REC 600V (PIV)	MOTOROLA	MR826
CR2		S/A CR1		
CR3	31003	1 DIODE, F/REC 600V (PIV)	MOTOROLA	1N4937
CR4		S/A CR1		
CR5		S/A CR1		
CR6	31013	1 SCR 2000 A/usec (di/dt)	AMPEREX	BTW63-800RK
CR7		S/A CR1		
CR8		S/A CR1		
CR9	31005	1 ZENER DIODE, 82V(Vz) 5W(Pd)	MOTOROLA	1N5375
CR10		S/A CR1		
CR11	31001	1 DIODE, G/P 1KV (PIV)	MOTOROLA	1N4007
CR12		NOT USED		
CR13	31009	2 DIODE, Si/SWIT 100V (PIV)	TEXAS INSTR.	1N914
CR14		S/A CR13		
CR15		S/A CR1		
DS1	34002	1 LED PANEL MOUNT, RED	IDI	5100H1
J1		N/U		
J2	14015	3 ISOLATED BNC	KING	KC-79-67
J3		S/A J2		
J4		S/A J2		
J5	14001	1 SHV BULKHEAD RECEPTACLE	KING	1704-1
J5A	14002	1 SHV PLUG	KING	1705-14
L1		NOT USED		
L2		1 COIL, 24T/in L=10.O uH	CCE	BW1T
Q1	32003	1 NPN HV/HC XSISTOR TO-39	MOTOROLA	2N5682
Q2	32001	2 NPN G/P XISTOR TO-18	MOTOROLA	2N2222
Q3		S/A Q2		
R1		1 100 OHMS 25W WW	OHMITE	L25J100
R2		N/U		
R3	24059	2 4.7 OHMS 2W CC	A-B	RC42
R4		S/A R3		
R5	24073	1 1.2M OHMS 2W CC	A-B	RC42
R6	24026	1 12K OHMS 1/2W CC	A-B	RC20
R7		NOT USED		
R8		NOT USED		
R9	24068	2 47K OHMS 2W CC	A-B	RC42
R10	24001	1 4.7 OHMS 1/2W CC	A-B	RC20
R11		NOT USED		
R12		NOT USED		
R13		NOT USED		
R14	24085	3 100 OHMS 1/4W CC	A-B	RC07
R15	24116	1 3.9K OHMS 1/4W CC	A-B	RC07
R16	24099	2 10K OHMS 1/4W CC	A-B	RC07
R17		S/A R16		
R18	24103	1 47K OHMS 1/4W CC	A-B	RC07
R19	24093	1 1K OHMS 1/4W CC	A-B	RC07
R20	24088	1 150 OHMS 1/4W CC	A-B	RC07
R21		S/A R14		
R22		S/A R14		
R23	24066	1 4.7K OHMS 2W CC	A-B	RC42
R24		S/A R12		
R25	24118	1 15K OHMS 1/4W CC	A-B	RC07
T1	52001	1 PULSE XFMR 1:4.8 2KV	MERZ	AE11458
T2	52004	1 PULSE XFMR 8:1	PULSE ENGR.	PE3016X
T3	52013	1 PULSE XFMR, 1:1	PULSE ENGR.	PE5156X
U1	33005	1 REGULATOR, 5V 500mA TO-220	MOTOROLA	MC78M05CT
U2	33003	1 TIMING CIRCUIT	MOTOROLA	MC1455P1



BREAKER
15A
K1
110VAC
INPUT
LINE
FILTER
20AAC
FL1
1.4KVA
STACO 1010
T1
T2
F1
F2
HV
INTERRUPT
RELAY
K2
HEATER
TIMER
RELAY
K3
110VAC HEATERS
& DRIVER
PS1
+24VDC
LOGIC
POWER
SUPPLY
PS2
+5VDC
LOGIC
POWER
SUPPLY
+24V
+5V
EMERGENCY OFF
ACCESS INTLK
EXTERNAL INTLK
INTERLOCK RELAYS
(4 RELAYS)
J1
TRIGGER
INPUT
J2
SYNC
OUTPUT
CR1
CR2
BRIDGE
RECTIFIERS
30KV
0.25A
CR3
CR4
R1 10M
R2 10M
R3 20.1K
C13
FILTER
2UF
15KV
C14
0.01uf
50V
POWER
SUPPLY
METER
M1
TOTAL CAPACITANCE,
0.012uf
4nf, EACH, CERAMIC
13KV
0.1A
C1
C2
C3
20K, 100W
R8
CHARGE CHOKE
5Hy
L1
50KV
1A
EDI KHP50
CR5
R4 10M
10K
R5
J3
CHARGE VOLTAGE
VIEW
20K
200W
R6
20K
200W
R7
PFN
DUMP
K5
DUMP
CONTROL
RELAY
K3
TRIGGER RESET
TRIGGER INTERLOCK
ST610-5
FIBER OPTIC
THYRATRON DRIVER
ST610-2
ST610-3
ST610-4
0.5A
F3
110 VAC
THYRATRON
L4915
HEATER TRANSFORMER
6.3V, 20A
T4
50KV
EDI KHP50
CR6
150
225W
TOTAL CAPACITANCE = 5NF
1.3NF EACH, CERAMIC
C4
C5
C6
C7
C8
25KV
EDI KHP25
CR7
75
225W
R10
1:4
PULSE
TRANSFORMER
T3
0.1
75W
R11
J4
PULSE CURRENT
VIEW
SHARPENING GAP
HIGH PRESSURE
HYDROGEN
100KV
OUTPUT
C9
C10
C11
C12
TOTAL CAPACITANCE,
20pf
100pf, EACH, CERAMIC
REVISIONS
LTR
DESCRIPTION
DATE
APVD
REFERENCE ONLY
PART NO.
NEXT ASSY.
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01
.XX ±0.005
∠±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.
DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER
C. C. E., INC.
TRIGGER GENERATOR
T-610
CAGECO
0Z887
DRAWING NO.
ST610-1
REV
B
SCALE
WEIGHT
SHEET
OF



REVISIONS			
LTR	DESCRIPTION	DATE	APVD

REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 | .XX ±0.005 | <±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

		DATE
DRAWN	B.W.W.	11-94
CHKR		
APPD		

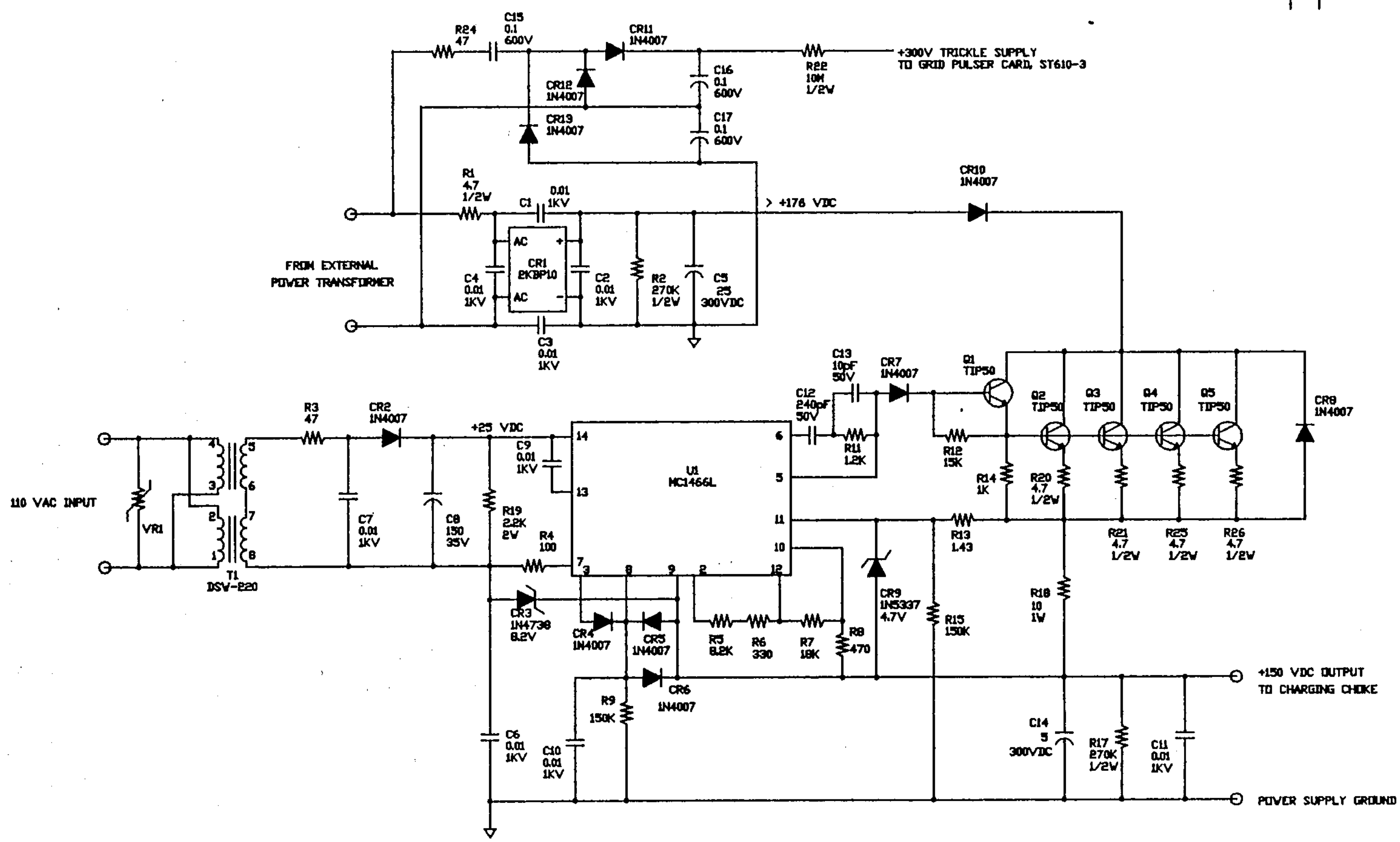
CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

THYRATRON GRID PULSER

SIZE | CAGECO 0Z887 | DRAWING NO. ST610-2 | REV A
SCALE N/A | WEIGHT | SHEET 2 OF 5

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY		
PART NO.	NEXT ASSY.	USED ON
APPLICATION		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01	.XX ±0.005	∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. √

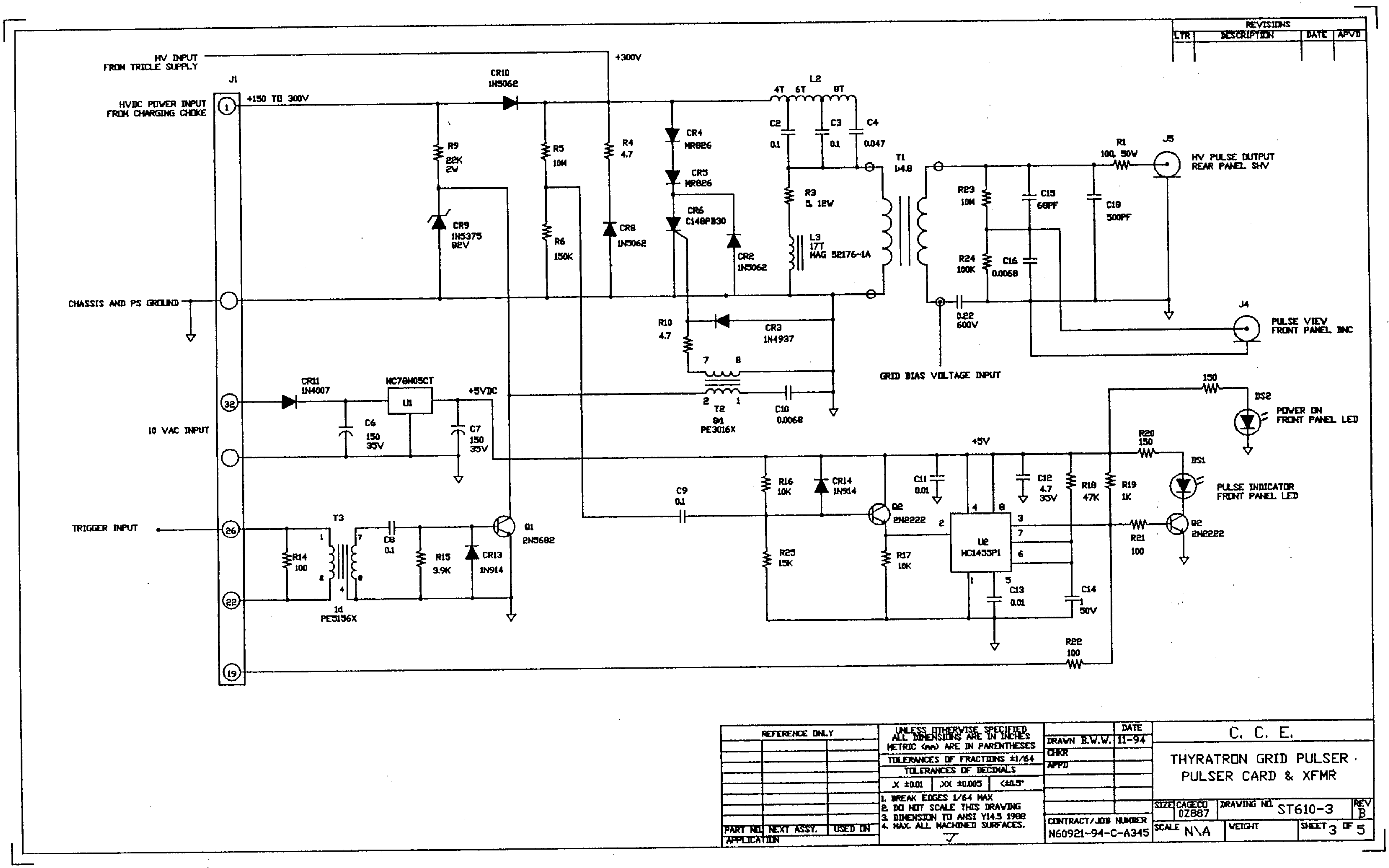
		DATE
DRAWN	B.W.W.	11-94
CHKR		
APPD		

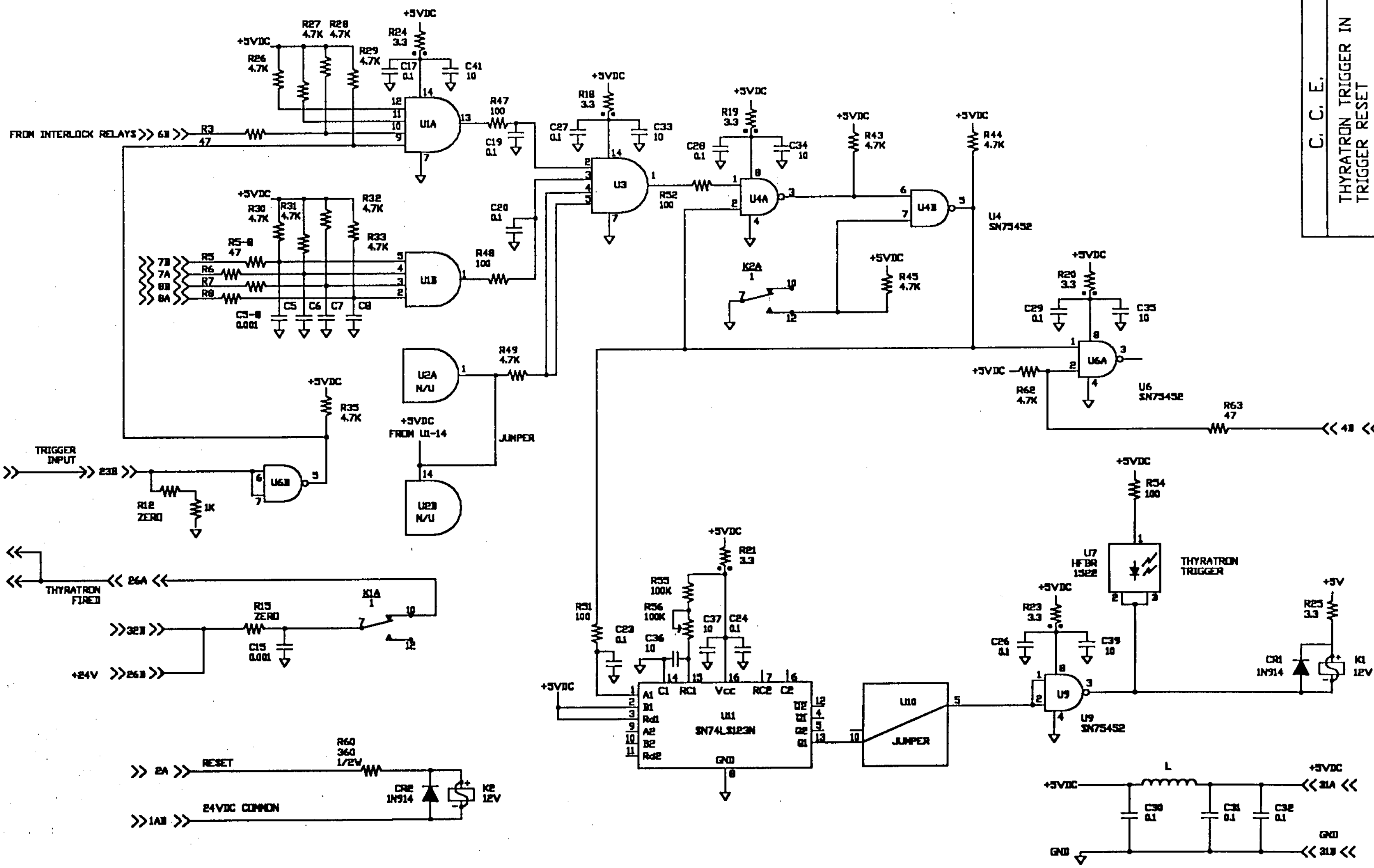
CONTRACT/JOB NUMBER N60921-94-C-A345

C. C. E.

POWER SUPPLY
GRID PULSER

SIZE	CAGECD 0Z887	DRAWING NO. ST610-4	REV B
SCALE N/A		WEIGHT	SHEET 4 OF 5


HV INPUT
FROM TRICLE SUPPLY
HVDC POWER INPUT
FROM CHARGING CHOKE
CHASSIS AND PS GROUND
10 VAC INPUT
TRIGGER INPUT
J1
+150 TO 300V
+300V
CR10
1N5062
R9
22K
2W
CR9
1N5375
82V
R5
10M
R6
150K
R4
4.7
CR8
1N5062
CR4
MR826
CR5
MR826
CR6
C148PB30
CR2
1N5062
L2
4T 6T 8T
C2
0.1
C3
0.1
C4
0.047
R3
5 12W
L3
17T
MAG 52176-1A
T1
1:4.8
R23
10M
R24
100K
C15
68PF
C16
0.0068
C18
500PF
R1
100 50V
J5
HV PULSE OUTPUT
REAR PANEL SHV
J4
PULSE VIEW
FRONT PANEL BNC
0.22
600V
GRID BIAS VOLTAGE INPUT
R10
4.7
CR3
1N4937
T2
PE3016X
C10
0.0068
CR11
1N4007
MC78M05CT
U1
+5VDC
C6
150
35V
C7
150
35V
T3
PE3156X
R14
100
C8
0.1
R15
3.9K
CR13
1N914
Q1
2N5682
C9
0.1
+5V
R16
10K
R25
15K
CR14
1N914
Q2
2N2222
R17
10K
C11
0.01
U2
MC1455P1
C13
0.01
C12
4.7
35V
R18
47K
C14
1
50V
R19
1K
R20
150
R21
100
R22
100
150
DS2
POWER ON
FRONT PANEL LED
DS1
PULSE INDICATOR
FRONT PANEL LED
REVISIONS
LTR
DESCRIPTION
DATE
APVD
REFERENCE ONLY
PART NO.
NEXT ASSY.
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01
.XX ±0.005
<±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.
DRAWN B.W.W.
DATE
11-94
CHKR
APPD
CONTRACT/JOB NUMBER
N60921-94-C-A345
C. C. E.
THYRATRON GRID PULSER
PULSER CARD & XFMR
SIZE
CAGECO
0Z887
DRAWING NO.
ST610-3
REV
B
SCALE
N\A
WEIGHT
SHEET 3 OF 5

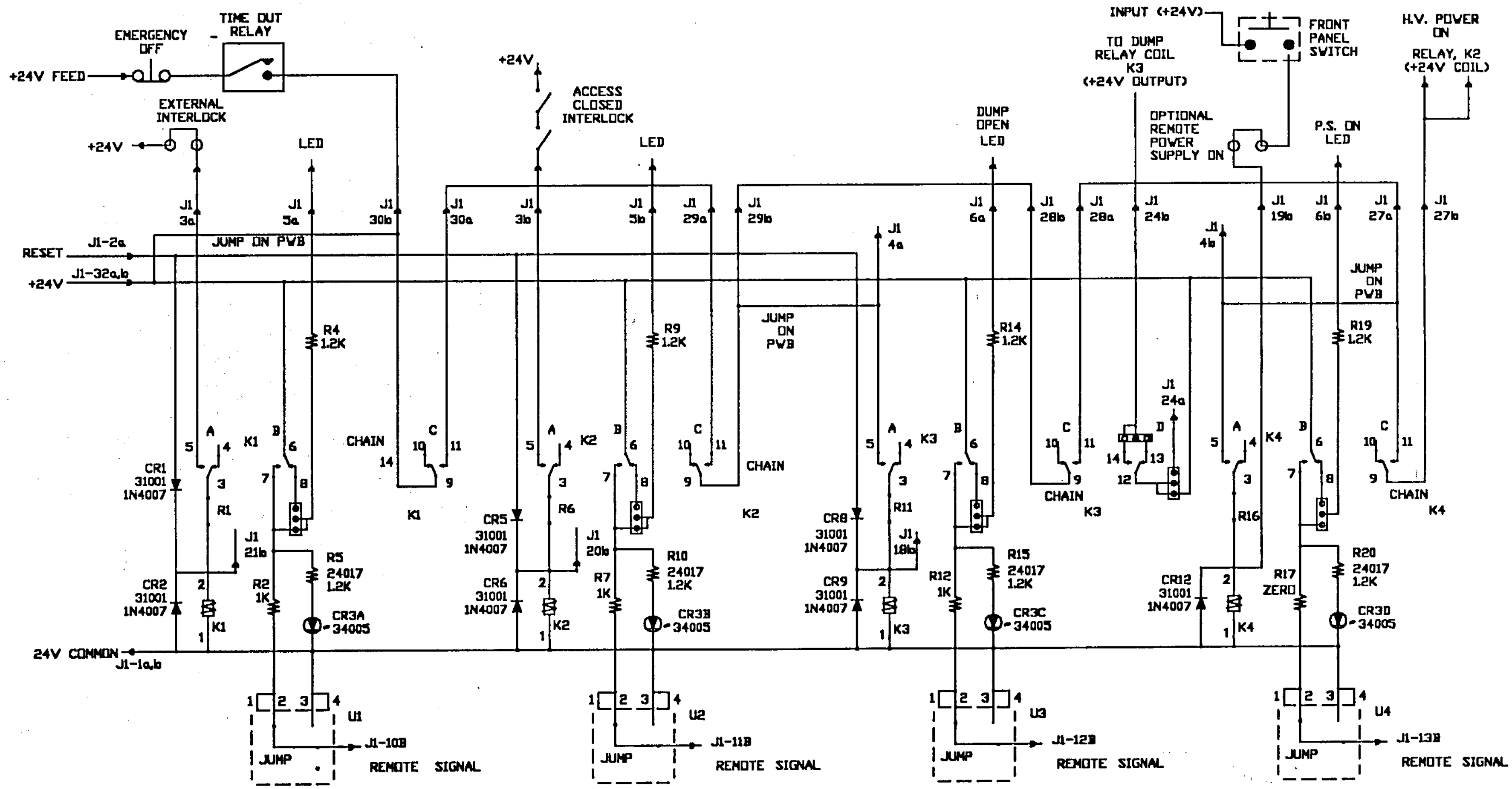


C. C. E.

THYRATRON TRIGGER IN
TRIGGER RESET
TRIGGER INTERLOCK

SIZE	CAGE CODE	DRAWING NO.	REV
D	02887	ST610-5	B

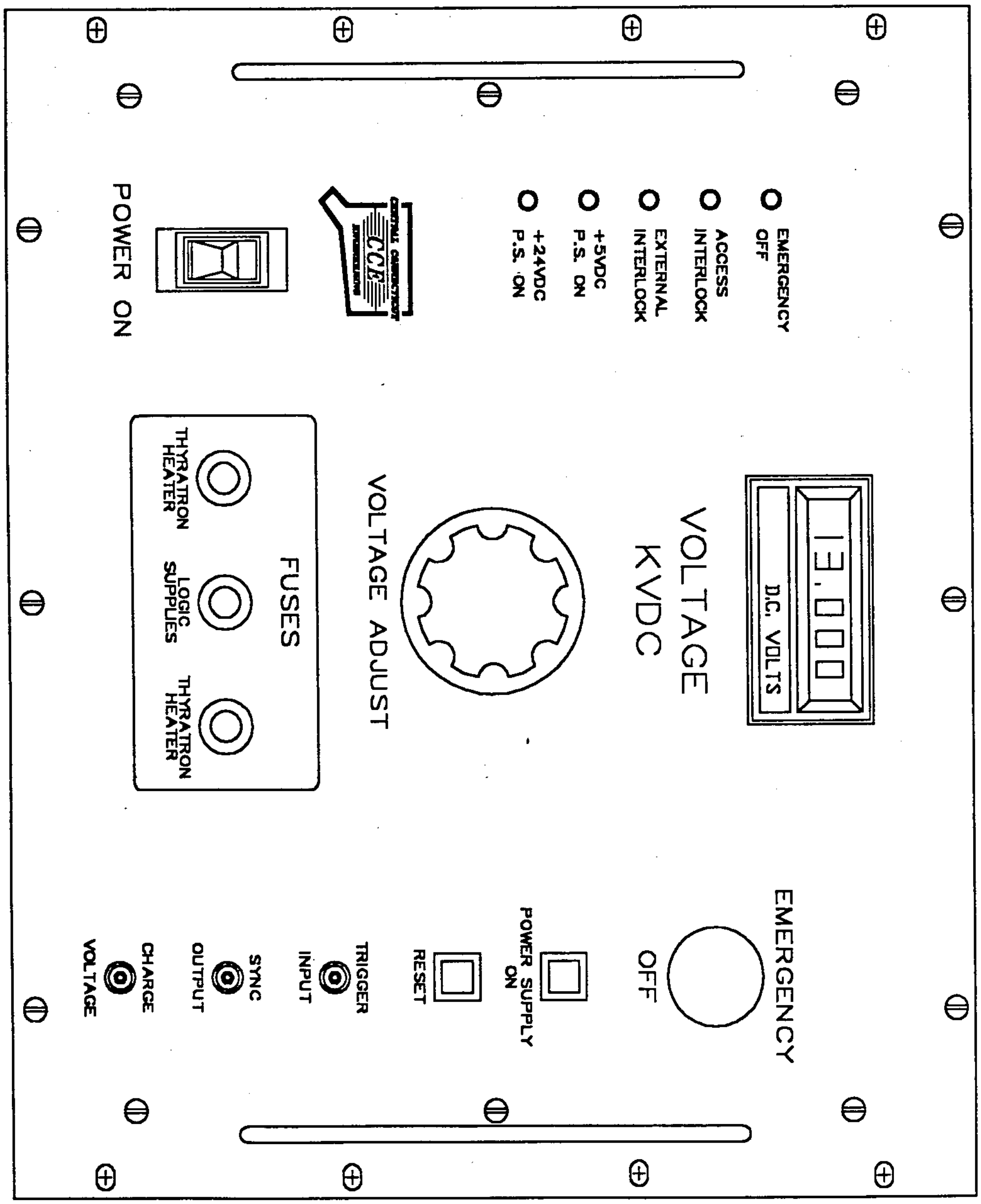
SCALE	WEIGHT	SHEET
N/A		3 OF 5



OPTIONAL REMOTE INTERFACE SIGNALS

ALL RELAYS AROMAT NF4-24V(-C)

DRWN	DATE	C C E, Inc.
APPRVD		INTERLOCK RELAYS
		D · CAGE CODE 0Z887 · DRAWING NUMBER ST610-6 · REV. A



REFERENCE ONLY			
PART NO.	NEXT ASSY.	USED ON	
APPLICATION			

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 .XX ±0.005 ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES.

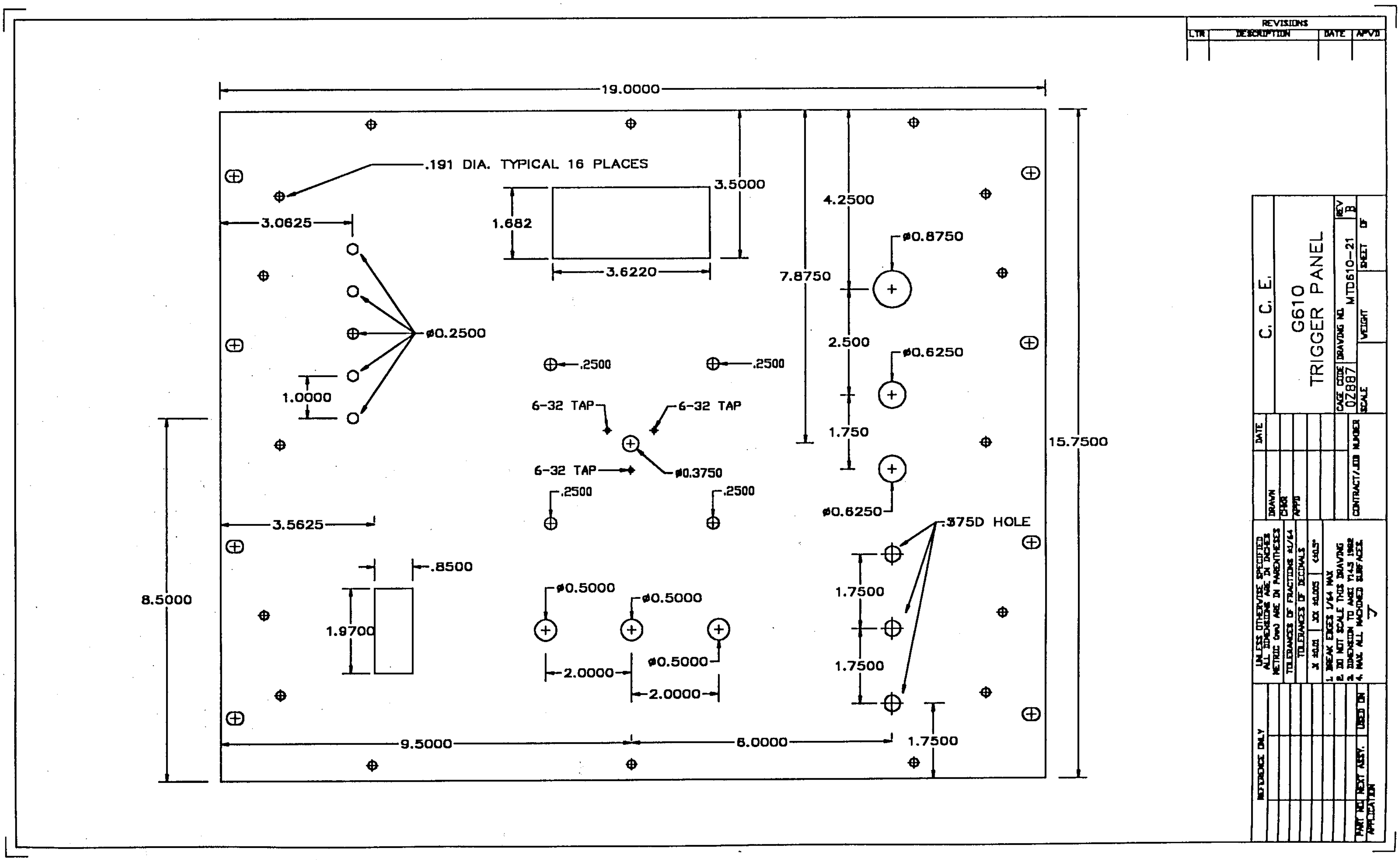
	DATE	
DRAWN		
CHKR		
APPD		
CONTRACT/JOB NUMBER		

C. C. E.

G610
TRIGGER PANEL

CAGE CODE	DRAWING NO.	REV
0Z887	MTD610-20	B
SCALE	WEIGHT	SHEET OF

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



C. C. E.
G610
TRIGGER PANEL
CAGE CODE 02887
DRAWING NO. MTD610-21
REV B
SCALE
WEIGHT
SHEET OF
REVISIONS
LTR DESCRIPTION DATE APVD
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES
TOLERANCES OF FRACTIONS ±1/64
TOLERANCES OF DECIMALS
.X ±0.01 .XX ±0.005 ±0.5°
1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX ALL MACHINED SURFACE
DRAWN
CHKR
APPD
DATE
CONTRACT/JOB NUMBER
REFERENCE ONLY
PART NO. NEXT ASSY. USED ON
APPLICATION
19.0000
15.7500
.191 DIA. TYPICAL 16 PLACES
3.0625
3.5000
1.682
3.6220
4.2500
7.8750
ø0.8750
2.500
ø0.6250
1.750
ø0.6250
ø0.2500
1.0000
.2500
6-32 TAP
ø0.3750
.375D HOLE
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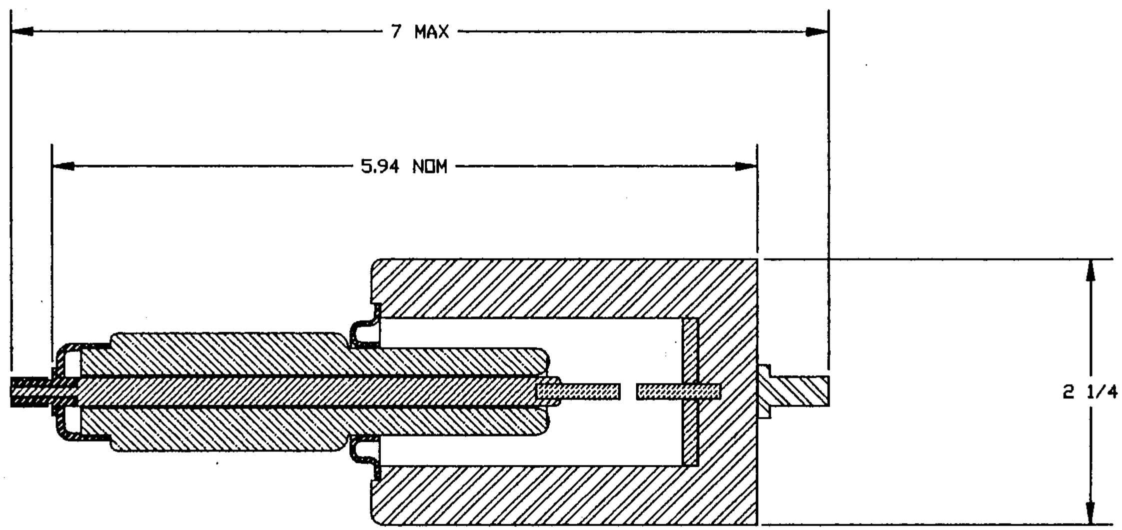
8.5000
9.5000
6.0000

REVISIONS			
LTR	DESCRIPTION	DATE	APVD



REFERENCE ONLY

PART NO. | NEXT ASSY. | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
METRIC (mm) ARE IN PARENTHESES

TOLERANCES OF FRACTIONS ±1/64

TOLERANCES OF DECIMALS

.X ±0.01 | .XX ±0.005 | ∠±0.5°

1. BREAK EDGES 1/64 MAX
2. DO NOT SCALE THIS DRAWING
3. DIMENSION TO ANSI Y14.5 1982
4. MAX. ALL MACHINED SURFACES. ✓

		DATE
DRAWN		
CHKR		
APPD		

CONTRACT/JOB NUMBER

C. C. E., INC.

DV 610
OVER-VOLTAGE GAP
BRAZED

CAGE CODE	DRAWING NO.	REV
0Z887	DV610-01	B

SCALE	WEIGHT	SHEET OF